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OZONE FORMATION STUDY: EMISSIONS INVENTORY REPORT

LOUISVILLE METRO AIR POLLUTION CONTROL DISTRICT

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ACRONYMS AND APPREVIATIONS

AQM	Air Quality Model
BenMAP	Benefits Mapping and Analysis Program
BenMAP-CE	Benefits Mapping and Analysis Program – Community Edition
CAMD	Clean Air Markets
CAMx	Comprehensive Air Quality Model with Extensions
CB6r4	Carbon Bond version 6 revision 4
CO	carbon monoxide
CPRM	coarse particulate matter
CSA	Combined Statistical Area
FEDOOP	Federally Enforceable District Origin Operating Permits
FIPS	Federal Information Processing Standard
FPRM	primary others
HONO	nitrous acid
HRVOCs	highly reactive Volatile Organic Compounds
IN	Indiana
IPP	Inventory Preparation Plan
km	kilometers
KY	Kentucky
lb/hour	pounds per hour
LMAPCD	Louisville Metro Air Pollution Control District
Louisville NAA	Louisville-Jefferson County, Kentucky-Indiana ozone nonattainment area
Louisville MSA	Louisville-Jefferson County Kentucky-Indiana Metropolitan Statistical Area
MJO	Multi-jurisdictional Organizations
MOVES	Motor Vehicle Emission Simulator
MSA	metropolitan statistical area
NAA	ozone nonattainment area
NAAQS	National Ambient Air Quality Standard
NH_3	ammonia
NOx	oxides of nitrogen
AQM	Air Quality Model
PM	particulate matter
$PM_{2.5}$	particulate matter with an aerodynamic diameter less than or equal to 2.5 microns
PM_{10}	particulate matter with an aerodynamic diameter less than or equal to 10 microns
PEC	primary elemental carbon
PNO_3	primary nitrate
POA	primary organic aerosol
POTW	Publicly Owned Treatment Works
ppb	parts per billion
ppm	parts per million
PSO_4	primary sulfate
QA	quality assurance
tpy	tons per year
SCC	Source Classification Code
SIP	State Implementation Plan
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	sulfur dioxide
SOx	sulfur dioxide
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds

EXECUTIVE SUMMARY

Overview of Study

On June 4, 2018, USEPA designated a portion of the Louisville/Jefferson County – Elizabethtown – Madison, Kentucky-Indiana Combined Statistical Area (CSA) as Marginal nonattainment for the 2015 ozone National Ambient Air Quality Standard (NAAQS), effective August 3, 2018. The Louisville CSA counties designated as nonattainment by USEPA for the 2015 ozone NAAQS included Bullitt, Jefferson, and Oldham in Kentucky (KY) and Clark and Floyd in Indiana (IN). The nonattainment designation was based on ozone design value[1] concentrations measured in 2014 through 2016 in the Louisville CSA (USEPA 2018a), when the Cannons Lane NCore monitoring site (site identifier 21-111-0067) had a 2014-2016 design value of 0.074 parts per million (ppm), exceeding the standard of 0.070 ppm.

On December 6, 2018, the USEPA finalized the Implementation Rule for the 2015 ozone NAAQS, which includes State Implementation Plan (SIP) requirements (Federal Register Volume 83 Number 234, p. 62998). Areas classified as Marginal nonattainment, such as the Louisville NAA, have 3 years from the date of designation to attain the standard (i.e., August 3, 2021 for the Louisville NAA). If the ozone design value monitored in the Louisville NAA continues to exceed the 2015 ozone NAAQS by the attainment date, the area could be reclassified to the more stringent "Moderate" nonattainment level. Moderate nonattainment levels have additional SIP requirements, including a requirement to demonstrate attainment by the future attainment date using an air quality model.

In order to better understand ozone precursor emissions and ozone formation processes in the Louisville/Jefferson County area, LMAPCD is undertaking this Ozone Formation Study. Ozone is formed in the atmosphere through a set of complex nonlinear photochemical reactions involving oxides of nitrogen (NOx) and Volatile Organic Compounds (VOCs) in the presence of sunlight. Louisville/Jefferson County has a unique emission source mixture. While Louisville/Jefferson County has conditions like many other urban areas containing an urban core surrounded by suburban and rural areas, the industrial sources in the county are highly diverse, both from the perspective of industrial activities (such as power generation, automotive manufacturing, chemical manufacturing, commercial product manufacturing, petroleum terminals, sewage treatment, landfills, etc.), as well as air quality emissions. Furthermore, some areas, such as Rubbertown, have a high density of highly reactive VOCs (HRVOCs) while other areas have relatively large distances between NOx emissions sources or low reactivity VOCs.

At this point in the Louisville Ozone Formation Study emissions inputs are being updated based on LMAPCD information and the resulting emissions inventory will be used in combination with other publicly available data in an AQM to assess:

1. The extent to which areas and periods of elevated ozone in Louisville NAA are NOx-limited or VOC-limited, and
2. For VOC-limited areas/periods, the ozone formation potential of VOC emissions.

This information can inform voluntary ozone reduction measures to attain compliance with the ozone NAAQS by the Marginal attainment date (August 3, 2021) as well as inform potential future control strategies should the area be reclassified to Moderate. Model results

[1] A design value is the monitored concentration reported in the form of the NAAQS. For both the 2008 and the 2015 ozone NAAQS, the design value is the 3-year average of the annual forth highest daily maximum 8-hour average ozone concentration.

can also be used to assess health effects using the USEPA Environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP-CE) model (AAI 2018).

Emissions Inventory Updates

For this study, available emissions from the USEPA have been updated to better represent additional information available for the Louisville area. Specifically, we have updated the USEPA 2016beta emissions inventories for onroad (mobile) sources, point sources, and nonpoint sources in the Louisville-Jefferson County area and surrounding counties. The USEPA and Multi-jurisdictional Organizations are co-developing a 2016 emissions inventory for multiple AQM purposes. The 2016beta Emissions Modeling Platform is the first product from the National Emissions Inventory Collaborative for year 2016, the most current year available.

Ramboll has incorporated onroad emissions generated by the LMAPCD into a revised 2016 base year emissions inventory. The LMAPCD has developed 2016 onroad inventory data for five counties in the Louisville MSA: Bullitt, Jefferson and Oldham counties in KY and Floyd and Clark counties in IN and provide them to Ramboll (Butler, 2019). As shown in Table ES-1, the onroad emissions provided by LMAPCD for the five county area are comparable to emissions developed by USEPA. Updated emissions are based on more refined local information.

Table ES-1. Updated Onroad Emissions for March through October Period Compared to the USEPA 2016beta inventory.

Updated Pollutants	Original 2016beta Emissions (tons)	Revised Emissions (tons)	% Total Difference
Ammonia (NH_3)	267	277	4%
Carbon monoxide (CO)	58,921	57,000	-3%
NO_X	9,828	12,034	22%
Particulate matter with an aerodynamic diameter of 10 microns or less (PM_{10})	770	792	3%
Particulate matter with an aerodynamic diameter of 10 microns or less ($PM_{2.5}$)	329	395	20%
Sulfur dioxide (SO_2)	49	82	67%
VOC	4,213	4,704	12%

In addition to the updates for the onroad sector, Ramboll revised the USEPA 2016beta nonpoint emissions for Louisville-Jefferson County based on synthetic minor source permit emissions supplied by LMAPCD (Gary, B., 2019a; Excel file "2016_lou_EI.xlsx"). Specifically, the LMAPCD provided Jefferson County emissions from sources permitted through Federally Enforceable District Origin Operating Permits (FEDOOP). The nonpoint source categories that were updated for this Ozone Formation Study include:

- Bulk Gas Terminals/Plants
- Waste Disposal: Publicly Owned Treatment Works (POTW)
- Industrial Natural Gas Combustion
- Land Clearing Debris

The revised emissions are shown in Table ES-2. Based on local data, the revised local Louisville emissions are less than estimated by the USEPA for bulk terminals and gasoline plants, are equivalent to the USEPA for POTWs, are increased relative to the USEPA for industrial natural gas combustion and are less than estimated by the USEPA for land clearing debris.

Table ES-2. Comparison of the USEPA 2016beta nonpoint inventory in tons per year to the revised emissions inventory

Source Category	Emissions Inventory	NH_3	CO	NO_X	PM_{25}	PM_{10}	VOC	SO_2
Bulk Plants and Terminals	Original 2016beta Emissions (tpy)	0.00	0.00	0.00	0.00	0.00	232.36	0.00
	Updated emissions (tpy)	0.00	0.00	0.00	0.00	0.00	138.68	0.00
POTW	Original 2016beta Emissions (tpy)	2.07	N/A	N/A	N/A	N/A	10.42	N/A
	Updated emissions (tpy)	2.07	23.55	28.25	17.77	10.42	10.42	1.21
Natural Gas Combustion	Original 2016beta Emissions (tpy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Updated emissions (tpy)	0.71	18.74	25.11	0.35	0.33	1.45	0.96
Land Clearing Debris	Original 2016beta Emissions (tpy)	N/A	5,426.9	160.6	420.83	545.90	372.49	53.31
	Updated emissions (tpy)	7.13	379.5	9.4	67.99	71.96	78.94	2.45
Total	Original 2016beta Emissions (tpy)	2.07	5,426.9	160.6	420.83	545.90	615.27	53.31
	Updated emissions (tpy)	9.91	421.8	62.8	86.11	82.71	229.49	4.62
Percent Difference		379%	-92%	-61%	-80%	-85%	-63%	-91%

The revised local Louisville emissions have been prepared for AQM using LMAPCD provided point source locations and emissions release parameters, if available, as well as USEPA default information related to:

1. timing of emissions throughout the ozone season or days of the week,
2. the location of emissions throughout the counties, and
3. the chemical speciation of the emissions.

Next Steps

Following LMACPD-approval of a final model-ready emissions inventory, the emissions inventory will be used in combination with other data required by the AQM to simulate ozone conditions in 2016 for the ozone season (March 1 through October 31). The model results will be compared to ozone monitored throughout the Louisville Nonattainment area to assess the model performance. If the model performs suitably, as defined by USEPA model performance guidance, the model will be used to better understand:

1. The extent to which areas and periods of elevated ozone in Louisville NAA are NOx-limited or VOC-limited, and
2. For VOC-limited areas/periods, the ozone formation potential of VOC emissions.

The findings from the AQM will be presented to LMAPCD in a draft and final report.

1. INTRODUCTION

This Emissions Inventory Report documents the data sources used and steps taken to compile a comprehensive 2016 base year emissions inventory of ozone precursors impacting ambient ozone levels in the Louisville Metro Area.

1.1 Background

On June 4, 2018, USEPA designated a portion of the Louisville/Jefferson County – Elizabethtown – Madison, Kentucky-Indiana Combined Statistical Area (CSA) as Marginal nonattainment for the 2015 ozone National Ambient Air Quality Standard (NAAQS), effective August 3, 2018 (Federal Register Volume 83, Number 107, p. 25776). The 2015 ozone NAAQS is 0.070 parts per million (ppm). The annual fourth-highest daily maximum 8-hour concentration averaged over 3 years is not to exceed the 2015 ozone NAAQS. The Louisville CSA counties designated as nonattainment by USEPA for the 2015 ozone NAAQS included Bullitt, Jefferson, and Oldham in Kentucky (KY) and Clark and Floyd in Indiana (IN). The nonattainment designation was based on ozone design value[2] concentrations measured in 2014 through 2016 in the Louisville CSA (USEPA 2018a), when the Cannons Lane NCore monitoring site (site identifier 21-111-0067) had a 2014-2016 design value of 0.074 ppm. The USEPA completed a 5-factor analysis to determine the nonattainment area boundaries and classification for the Louisville, KY-IN nonattainment area (USEPA 2018a). The Louisville-Jefferson County Kentucky-Indiana ozone nonattainment area is referred to as the Louisville NAA.

On December 6, 2018, the USEPA finalized the Implementation Rule for the 2015 ozone NAAQS, which includes State Implementation Plan (SIP) requirements (Federal Register Volume 83 Number 234, p. 62998). Areas classified as Marginal nonattainment, such as the Louisville NAA, have 3 years from the date of designation to attain the standard (i.e., August 3, 2021 for the Louisville NAA). If an ozone monitor in the Louisville NAA exceeds the 2018 ozone NAAQS during the 2018-2020 ozone season, the area could be reclassified to the more stringent “Moderate” nonattainment level. Moderate nonattainment levels have additional SIP requirements, including a requirement to demonstrate attainment by the future attainment date using an air quality model.

In order to better understand ozone precursor emissions and ozone formation processes in the Louisville/Jefferson County area, LMAPCD is undertaking this Ozone Formation Study. Ozone is formed in the atmosphere through a set of complex nonlinear photochemical reactions involving oxides of nitrogen (NOx) and Volatile Organic Compounds (VOCs) in the presence of sunlight. Ozone formation within Louisville NAA has previously been characterized as being either NOx-limited or VOC-limited (radical-limited); for example, typically earlier in the day ozone formation is limited by the rate of radical initiation so is more VOC (radical)-limited and by the afternoon, when photochemical reactions are greatest, ozone formation tends to be more NOx-limited. The level of precursor limitation can also vary greatly across an urban area. For example, in areas with high NOx emissions (such as urban downtowns where mobile source emissions predominate or downwind of large NOx point sources) ozone formation may be more VOC-limited, while a few km away in the suburbs ozone formation may be more NOx-limited. Beyond a certain ratio of VOC to NOx, however, further NOx reductions may act to increase ozone formation through radical

[2] A design value is the monitored concentration reported in the form of the NAAQS. For both the 2008 and the 2015 ozone NAAQS, the design value is the 3-year average of the annual forth highest daily maximum 8-hour average ozone concentration.

initiated reactions of VOC and subsequent photochemical reactions that produce ozone, the so-called NOx disbenefit.

Louisville/Jefferson County has a unique heterogenous source mixture. While Louisville/Jefferson County has conditions like many other urban areas containing an urban core surrounded by suburban and rural areas, the industrial sources in the county are highly diverse, both from the perspective of industrial activities (such as power generation, automotive manufacturing, chemical manufacturing, commercial product manufacturing, petroleum terminals, sewage treatment, landfills, etc.), as well as air quality emissions. Furthermore, some areas, such as Rubbertown, have a high density of highly reactive VOCs (HRVOCs) while other areas have relatively large distances between NOx emissions sources or low reactivity VOCs.

A photochemical model is the best tool to assess spatial and temporal variations in ozone formation, as found in Louisville/Jefferson County, and analyze the sensitivity of ozone formation to NOx versus VOC precursors. Photochemical models are also the USEPA recommended tool for ozone modeling (USEPA 2018a). In order to better understand the ozone formation processes contributing to elevated periods of ozone in Louisville/Jefferson County, ozone modeling will be conducted with an existing air quality model (AQM) with an existing air quality database.

Emissions inputs were refined based on LMAPCD information to better represent the unique source characteristics and emissions profiles in Louisville/Jefferson County, as described in Louisville Metropolitan Air Pollution Control District Emissions Inventory Quality Assurance Project Plan (Ramboll 2019) and this Draft Emissions Inventory Report. The emissions inputs generated specifically for the Louisville Ozone Formation Study will be used in combination with other publicly available data in an AQM to assess:

1. The extent to which areas and periods of elevated ozone in Louisville NAA are NOx-limited or VOC-limited, and
2. For VOC-limited areas/periods, the ozone formation potential of VOC emissions.

This information can inform voluntary ozone reduction measures to attain compliance with the ozone NAAQS by the Marginal attainment date (August 3, 2021) as well as inform potential future control strategies should the area be reclassified to Moderate. Model results can also be used to assess health effects using the USEPA Environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP-CE) model (AAI 2018).

1.2 Louisville-Jefferson County Unique Source Composition

Louisville NAA has a unique source mix comprised of a variety of industrial source sectors, mobile sources and biogenic emissions. The locations and magnitudes of NOx and VOC emissions sources from the industrial sector are shown in Figure 1 for the Louisville-Jefferson County Kentucky-Indiana Metropolitan Statistical Area (referred to as the Louisville MSA) based on the 2014 NEIv2 (USEPA 2018b). As shown in the Figure, some sources emit both NOx and VOC, but several geographic areas, such as Rubbertown, the NOx and VOC emissions are not correlated.

Of further relevance for this study is that the VOC emissions sources often have unique and temporally varied composition. The VOC composition is a critical component of this study for the accurate assessment of ozone sensitivity to NOx versus VOC and the VOC ozone formation potential. Available data from the USEPA Air Toxics Monitoring Project funded via Regional Applied Research Effort (RARE) may be particularly useful for this study to assess the quality of the speciated VOC emissions inventory and inform emissions inventory development efforts.

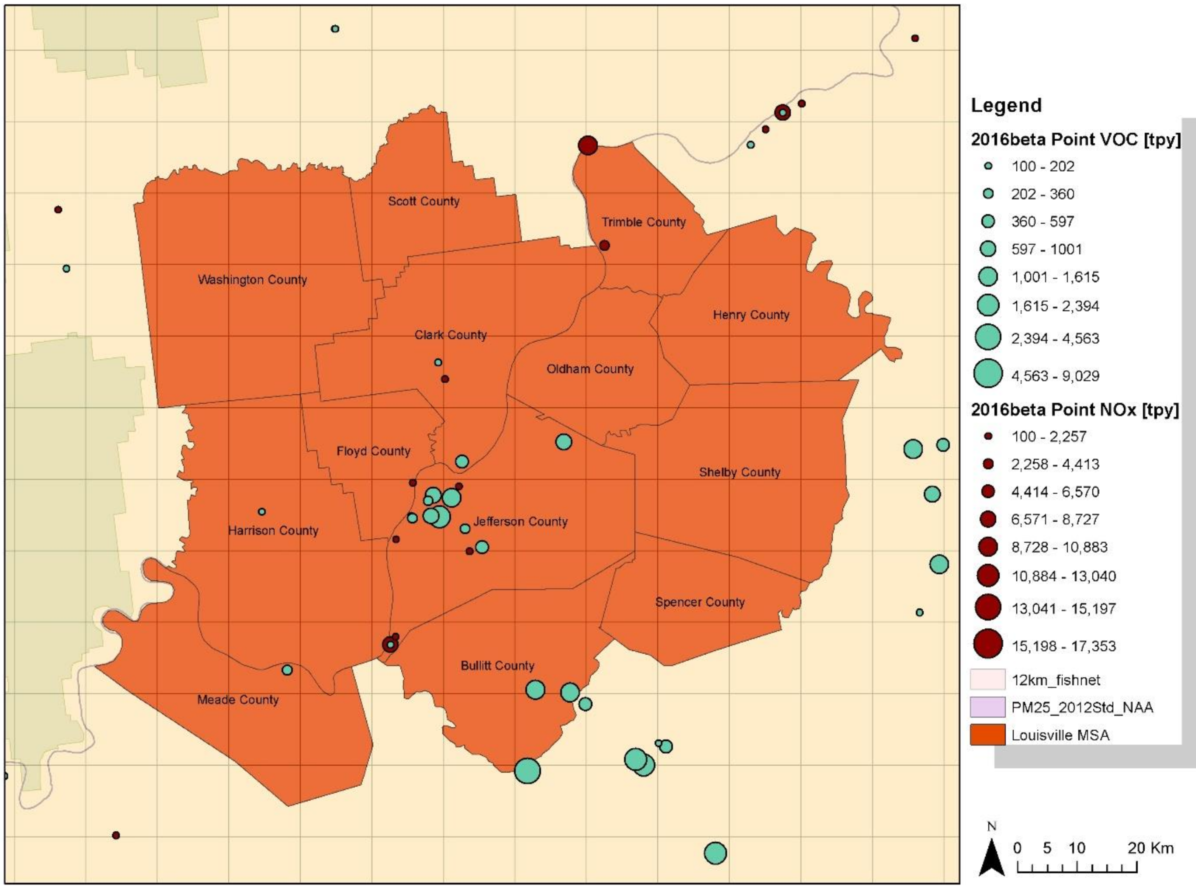

Figure 1. NOx and VOC emissions sources in the vicinity of Louisville MSA.

1.3 Overview of Emissions Inventory Refinements

The 2016beta inventory developed by the USEPA formed the framework of the modeling emissions for the Louisville Ozone Formation Study. The USEPA emissions data have been updated for key inventory sources to better represent the Louisville NAA and surrounding counties, wherever feasible. The emissions inventory updates include the following characteristics:

- Pollutants: The pollutants included in the emissions inventory are as follows:
  - Ozone precursors: nitrogen oxides (NOx), volatile organic compounds (VOC), and CO;
  - Primary PM_{10} and $PM_{2.5}$;
  - Precursors of PM_{10} and $PM_{2.5}$: NOx, sulfur dioxide (SOx), VOC, and ammonia (NH_3); and
  - Selected HAPs: Naphthalene, Benzene, Acetaldehyde, Formaldehyde and Methanol.

- Time Frame and Temporal Resolution: The base year inventory is developed for year 2016. Although the ozone season being modeled is March 1 through October 31, the base year inventory is comprised of: 1) annual emissions that are apportioned to months and seasons of the year and 2) monthly emissions for onroad sector.
- Emissions Source Type: The inventory has been updated for industrial point sources within Louisville/Jefferson County, nonpoint area sources within Louisville/Jefferson County, and onroad mobile sources within five counties in the Louisville MSA.

2. EMISSIONS DATA SOURCES

The USEPA and Multi-jurisdictional Organizations (MJOs) are co-developing a 2016 AQM platform. The 2016beta Emissions Modeling Platform (EMP) is the first product from the National Emissions Inventory Collaborative that includes a full suite of base year (2016) and future year inventories, ancillary emissions data, and scripts and software for preparing the emissions for air quality modeling[3]. Details on the 2016beta platform development is available on its wiki[4].

The 2016beta inventory is the basis for the emissions for this study. The USEPA developed the 2016beta model-ready emissions for the 12-km continental US domain (12US1) and a 36-km US3 domain (36US3) shown in Figure 2. Ramboll has obtained the 2016beta EMP gridded, pre-merged emissions from the USEPA for this study. The emissions dataset includes a full set of emissions required for use in an AQM, including anthropogenic emissions and natural emissions such as biogenic and fires. For this study, the USEPA 2016beta anthropogenic emissions data has been updated to better represent additional information available for the Louisville NAA. Specifically, we have updated the USEPA 2016beta inventories for onroad (mobile) sources, point sources, and nonpoint sources.

The following sections detail the sources of new emissions data and compare the revised emissions to the original USEPA 2016beta EMP.

2.1 Onroad Mobile Emissions

Ramboll has incorporated onroad emissions generated by the LMAPCD into a revised 2016 base year emissions inventory. The LMAPCD has developed 2016 onroad inventory data for five counties in the Louisville MSA: Bullitt, Jefferson and Oldham counties in KY and Floyd and Clark counties in IN and provide them to Ramboll (Butler, 2019; Excel file "APCD 2016 onroad emissions 5 counties.xlsx"). The emissions data has been generated with the EPA MOVES model, version 2014b (USEPA, 2014a,b,c) in inventory mode for the 8 ozone months (March through October). The inventory data provided by LMAPCD consists of monthly total emissions by Source Classification Code (SCC) for the five counties. The following local data sets for MOVES input were used:

- Vehicle age distribution, using state transportation-supplied VIN-decoded vehicle registration data
- Source type population of vehicles, using state transportation-supplied VIN-decoded vehicle registration data
- Road type VMT fractions, using MPO (KIPDA) supplied VMT data
- Ramp VMT fractions, using MPO (KIPDA) supplied VMT data
- Average VMT speed distribution (by vehicle and road type), using MPO (KIPDA) supplied VMT data
- VMT by vehicle type, using both state vehicle and MPO supplied VMT data
- Meteorology from a nearby NOAA meteorology station data (Louisville Muhammad Ali International Airport)

3 National Emissions Inventory Collaborative (2019). 2016beta Emissions Modeling Platform. Retrieved from http://views.cira.colostate.edu/wiki/wiki/10197.

4 http://views.cira.colostate.edu/wiki/wiki/9169

MOVES default inputs were used for hourly, daily and monthly VMT fractions; fuel supply; fuel formulation; alternative vehicle fuel technologies; and fuel usage fractions. There were no inspection and maintenance programs in force for any of the five counties for 2016.

Ramboll evaluated the LMAPCD-provided county-level onroad emissions against what is in the USEPA 2016beta EMP. The USEPA generated onroad mobile emissions directly on the 12-km model grid rather than county-level totals using SMOKE-MOVES processing approach. The gridded emissions were summarized by county using grid cells masking approach and compared against the LMAPCD emissions by month. Table 1 shows a comparison of onroad emissions between the USEPA 2016beta and MOVES inventory provided by LMAPCD, for Bullitt, Clark, Floyd, Jefferson and Oldham Counties.

It should be noted that there are some inputs and processing differences in how the two estimates are developed:

1. The USEPA onroad emissions are calculated based on hourly gridded meteorological data, whereas MOVES inventory mode uses county-average mereological data for each month
2. Some MOVES inputs were updated using local information in the LMAPCD inventory
3. The USEPA 2016beta onroad emissions are extracted for 12-km grid cells and are not exact estimates of county-level emissions

The purpose of this comparison is to make sure that there are no substantial differences between the two emissions datasets. As shown in Table 1, the two datasets are comparable. In cases where there are larger differences between the two datasets values are still within the expected range given that the USEPA emissions are not exact estimates of total county onroad emissions.

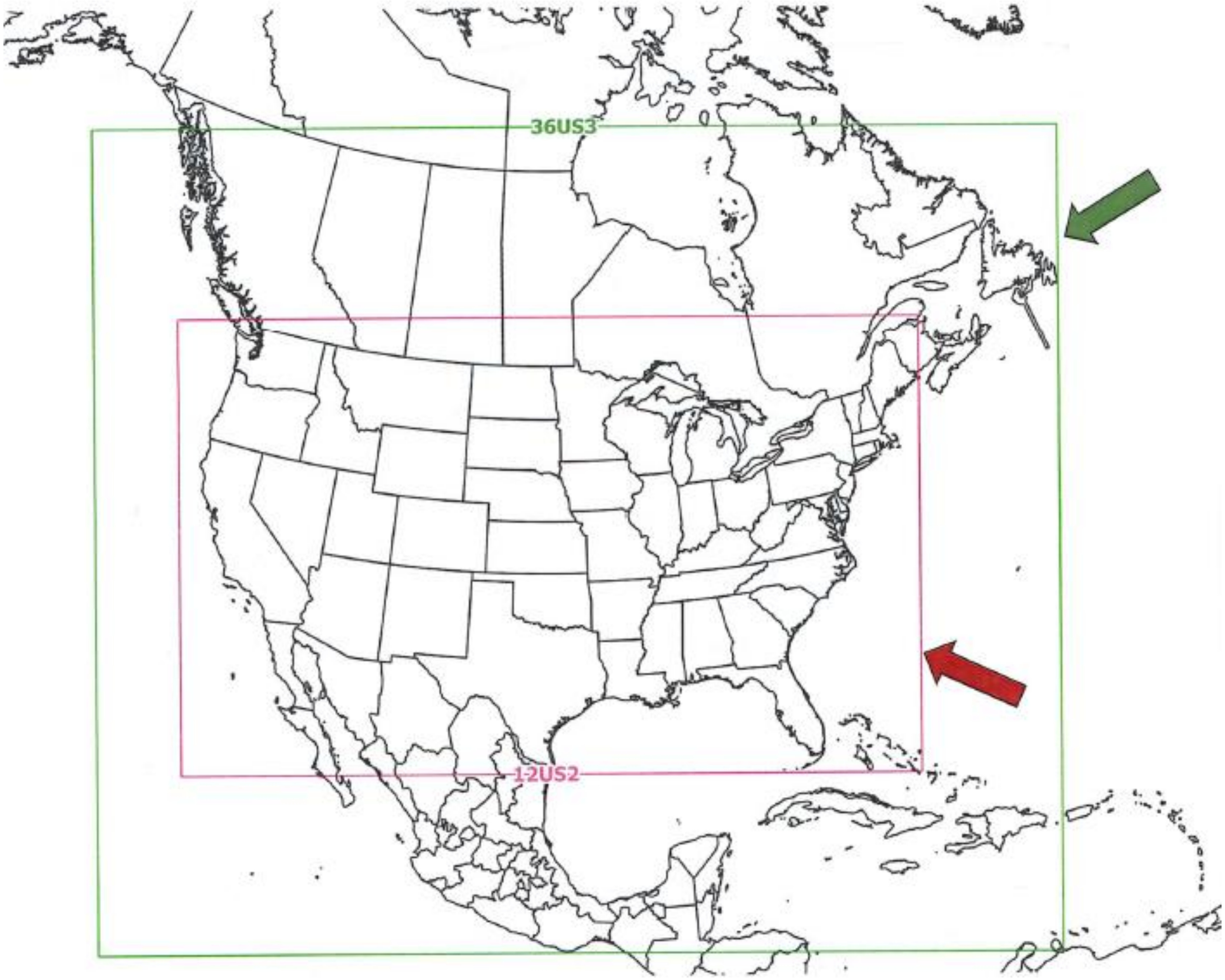

Figure 2. 12-km (12US2/CONUS2) and 36-km (36US3) domains used in the 2016 modeling platform.

Table 1. Onroad Emissions Comparison between 2016beta Platform and LMAPCD MOVES2014b inventory for five counties in the Louisville MSA.

Emissions (in tons; March-Oct period)	EPA 2016beta	LMAPCD MOVES	%Difference
Ammonia (NH_3)			
Bullitt_KY	27.6	25.1	-9.16%
Clark_IN	34.1	39.4	15.36%
Floyd_IN	26.7	22.7	-14.72%
Jefferson_KY	164.8	177.8	7.85%
Oldham_KY	14.2	12.0	-15.23%
Carbon Monoxide (CO)			
Bullitt_KY	6,208.1	4,821.5	-22.34%
Clark_IN	6,459.6	8,338.1	29.08%

Emissions (in tons; March-Oct period)	EPA 2016beta	LMAPCD MOVES	%Difference
Floyd_IN	5,493.3	6,441.0	17.25%
Jefferson_KY	37,365.4	35,025.2	-6.26%
Oldham_KY	3,394.4	2,373.9	-30.07%
Oxides of Nitrogen (NOx)			
Bullitt_KY	1,321.1	1,506.4	14.03%
Clark_IN	1,390.3	2,050.0	47.45%
Floyd_IN	1,003.1	1,287.3	28.34%
Jefferson_KY	5,468.7	6,549.0	19.75%
Oldham_KY	644.6	641.1	-0.55%
Primary PM_{10} - Total			
Bullitt_KY	82.2	78.8	-4.12%
Clark_IN	98.5	123.5	25.42%
Floyd_IN	76.3	76.0	-0.42%
Jefferson_KY	462.8	471.6	1.89%
Oldham_KY	49.8	42.4	-14.94%
Primary $PM_{2.5}$ - Total			
Bullitt_KY	40.4	47.5	17.55%
Clark_IN	46.9	63.2	34.89%
Floyd_IN	34.2	38.8	13.44%
Jefferson_KY	185.1	222.1	19.95%
Oldham_KY	22.3	23.4	4.75%
Sulfur Dioxide (SO_2)			
Bullitt_KY	4.9	7.1	43.37%
Clark_IN	7.4	10.8	45.55%
Floyd_IN	5.6	6.5	15.47%
Jefferson_KY	28.4	54.0	90.30%
Oldham_KY	2.6	3.9	50.20%
Volatile Organic Compounds			
Bullitt_KY	455.0	447.3	-1.71%
Clark_IN	478.8	669.0	39.73%
Floyd_IN	427.7	721.0	68.57%
Jefferson_KY	2,577.1	2,645.2	2.64%
Oldham_KY	274.6	221.5	-19.33%

2.2 Nonpoint Emissions

Ramboll revised the USEPA 2016beta EMP nonpoint emissions for Louisville-Jefferson County based on synthetic minor source permit emissions supplied by LMAPCD (Gary, B., 2019a; Excel file "2016_lou_EI.xlsx"). Specifically, the LMAPCD provided Jefferson County emissions from sources permitted through Federally Enforceable District Origin Operating Permits (FEDOOP). Ramboll isolated the SCC codes in the USEPA 2016beta EMP nonpoint source emissions file that correspond with the LMAPCD-supplied emissions and updated the nonpoint emissions file for those SCC codes. Nonpoint source emissions are typically estimated by USEPA using a top-down approach with county-level activity data and it can be challenging to reconcile county-level emissions with a source-specific inventory. Therefore, for completeness reasons, only selected SCC in the 2016beta EMP were updated when a complete county-level emission inventory is quantified by the LMAPCD. The source categories that met this requirement and were updated for this study's revised inventory include:

- Bulk Gas Terminals/Plants
- Waste Disposal: Publicly Owned Treatment Works (POTW)
- Industrial Natural Gas Combustion
- Land Clearing Debris

The following sections detail the new nonpoint emissions data and compare the revised emissions to the original USEPA 2016beta EMP.

2.2.1 Bulk Gas Terminals/Plants

The USEPA 2016beta platform inventory contains more emissions for gasoline terminals and plants than reported to the LMAPCD by FEDOOP sources. As shown in Table 2, the USEPA 2016beta EMP contains roughly 150 tons of VOC emissions for gasoline terminals (SCC 2501050120) and 80 tons for bulk plants (SCC 2501055120). The total VOC for all gasoline bulk facilities in Louisville reported through FEDOOP is less than 150 tons. Based on the 40 CFR Part 63.11100, the distinction between bulk terminals and bulk plants is that bulk terminals have the potential to handle greater than 20,000 gallons/day. All bulk gasoline facilities in Louisville had greater than that throughput in 2016, and so by definition are considered bulk terminals. This means the bulk plants (SCC 2501055120) should have zero emissions and all gasoline terminal emissions are attributed to bulk terminal classification (SCC 2501050120). Table 2 shows the difference between the updated emissions and the original USEPA 2016beta EMP nonpoint emissions.

All emissions associated with bulk plants in the USEPA 2016beta nonpoint emissions have been replaced with emissions provided by LMAPCD. Emissions associated with bulk terminals were converted into point source format based on facility location. Location information was provided by the LMAPCD (Gary, B., 2019a; Excel file "2016_lou_EI.xlsx" tab "plant_info") and values are shown in Table 3.

Table 2. Emissions updates for bulk terminals/plants in the USEPA 2016beta inventory.

Source Category	SCC	Updated Pollutants	Original 2016beta Emissions (tons per year [tpy])	Updated emissions (tpy)		% Total Difference
				Nonpoint	Point	
Bulk Plant	2501055120	VOC	78.27	0	0	-100%
Bulk Terminal	2501050000	VOC	N/A	N/A	5.79	N/A
Bulk Terminal	2501050030	VOC	N/A	N/A	0.32	N/A
Bulk Terminal	2501050090	VOC	N/A	N/A	3.11	N/A
Bulk Terminal	2501050120	VOC	154.09	0	129.46	-16%

Table 3. Point emissions for bulk terminals.

Facility ID	Facility name	SCC	Pollutant	Emissions (tpy)	Longitude	Latitude
84	Buckeye Terminals, LLC	2501050000	VOC	0.01	-85.8333	38.2326
84	Buckeye Terminals, LLC	2501050090	VOC	0.94	-85.8333	38.2326
84	Buckeye Terminals, LLC	2501050120	VOC	29.19	-85.8333	38.2326
143	MPLX Terminals, LLC	2501050000	VOC	2.82	-85.8481	38.2058
143	MPLX Terminals, LLC	2501050090	VOC	1.48	-85.8481	38.2058
143	MPLX Terminals, LLC	2501050120	VOC	39.36	-85.8481	38.2058
214	Valero Terminaling and Distribution Company	2501050000	VOC	2.78	-85.8335	38.2281
214	Valero Terminaling and Distribution Company	2501050030	VOC	0.32	-85.8335	38.2281
214	Valero Terminaling and Distribution Company	2501050090	VOC	0.69	-85.8335	38.2281
214	Valero Terminaling and Distribution Company	2501050120	VOC	46.31	-85.8335	38.2281
220	Thornton Transportation LLC	2501050000	VOC	0.18	-85.8977	38.1402

220	Thornton Transportation LLC	2501050120	VOC	13.51	-85.8977	38.1402
341	VALOR, LLC	2501050120	VOC	1.09	-85.8408	38.2233

2.2.2 Waste Disposal: Publicly Owned Treatment Works (POTW)

The LMAPCD provided emissions data for the Morris Forman Waste Water Treatment Plant (WWTP), as well as release point characteristics such as stack height, diameter, exit velocity etc. (Gary, B., 2019b; Excel file "2019-05-24_MFWWTP_processes" and "2019-05-24_MFWWTP_rel_pts"). Those emissions have been converted into point source format for SMOKE processing. Emissions associated with the Morris Forman WWTP were subtracted from the USEPA 2016beta nonpoint inventory for SCC 263002000 in order to retain emissions for other small plants in the county. The updated emissions are shown in Table 4. Table 5 is a summary table of the new point emissions created for the Morris Forman WWTP.

Table 4. Emissions updates for POTW in the USEPA 2016beta inventory.

SCC	Updated pollutants	Original 2016beta Emissions (tpy)	Updated emissions (tpy)		%Total Difference
			Nonpoint	Point	
2630020000	NH_3	2.07	1.17	0.8958	0%
2630020000	VOC	10.42	3.99	6.4339	0%
2630020000	CO	N/A	N/A	23.5493	N/A
2630020000	NO_X	N/A	N/A	28.247	N/A
2630020000	PM_{10}-PRI	N/A	N/A	17.7735	N/A
2630020000	PM_{25}-PRI	N/A	N/A	10.4187	N/A
2630020000	SO_2	N/A	N/A	1.2062	N/A

Table 5. Aggregated Morris Forman WWTP emissions by pollutants.

Facility ID	Facility name	SCC	Pollutant	Annual value	Longitude	Latitude
149	Metropolitan Sewer District, Morris Forman WWTP	2630020000	CO	23.5493	-85.8349	38.2305
149	Metropolitan Sewer District, Morris Forman WWTP	2630020000	NH_3	0.8958	-85.8349	38.2305
149	Metropolitan Sewer District, Morris Forman WWTP	2630020000	NO_X	28.2470	-85.8349	38.2305
149	Metropolitan Sewer District, Morris Forman WWTP	2630020000	PM_{10}-PRI	17.7735	-85.8349	38.2305
149	Metropolitan Sewer District, Morris Forman WWTP	2630020000	PM_{25}-PRI	10.4187	-85.8349	38.2305
149	Metropolitan Sewer District, Morris Forman WWTP	2630020000	SO_2	1.2062	-85.8349	38.2305

149	Metropolitan Sewer District, Morris Forman WWTP	2630020000	VOC	6.4339	-85.8349	38.2305

2.2.3 Industrial Natural Gas Combustion

The 2016beta inventory contains zero emissions for industrial natural gas combustion (SCC 2102006000). Based on the reported data to the LMAPCD, it seems unlikely to have zero emissions for this source category (Gary, B., 2019b). In the 2016beta inventory, the estimates are based on fuel usage for the state, downscaled to county estimates based on population, minus the actual emissions from the point sector developed using the EPA ICI Tool[5]. It is likely that the point emissions were as large or larger than that EPA ICI Tool county-level estimates and the resulting nonpoint emissions were zero as a result.

The LMAPCD provided Ramboll with 2016 emissions data from natural gas boilers and natural gas internal combustion engines that are not included in the point source inventory (Gary, B., 2019b). These emissions were used to replace the existing USEPA 2016beta emissions for SCC 2102006000. New emissions numbers are shown in Table 6.

Table 6. Emissions updates for industrial natural gas combustion in the USEPA 2016Beta nonpoint EI

SCC	Updated pollutants	Original 2016beta Emissions (tpy)	Updated emissions (tpy)
2102006000	CO	0	18.74
2102006000	NH_3	0	0.71
2102006000	NO_X	0	25.11
2102006000	PM_{10}-PRI	0	0.35
2102006000	PM_{25}-PRI	0	0.33
2102006000	VOC	0	1.45
2102006000	SO_2	0	0.96

2.2.4 Land Clearing Debris

While reviewing the nonpoint inventory data for Jefferson County, it was noted that the emissions associated with land clearing debris were higher than anticipated in the 2016beta platform considering the LMAPCD explicitly prohibits open burning for land clearing in local regulations (only allowing it for recognized agricultural purposes). Open burning of land clearing debris is defined as the purposeful burning of debris, such as trees, shrubs, and brush, from the clearing of land for the construction of new buildings and highways.

The LMAPCD ran the BlueSky Playground tool (U.S. Forest Service, 2019) using acreage estimates from agricultural burning permits for 2016 and with two fuel types (ID 443 “Prairie Cordgrass” and ID 133 “Tall Fescue”) suggested by the USEPA, as well as the fuel type suggested by the tool for the Louisville area (ID 269 “Sugar maple/yellow poplar”). The fuel type ID 269 produced the largest emissions of the three fuel types and was used to update the inventory to result in conservatively high estimates of emissions. As shown

[5] Available at ftp://ftp.epa.gov/EmisInventory/2014/doc/nonpoint

in Table 7, there is a reduction across all pollutants except NH_3, which was not included in the USEPA 2016beta nonpoint platform for SCC 261000500.

Table 7. Emissions updates for land clearing debris in the USEPA 2016beta nonpoint inventory

SCC	Updated pollutants	Original 2016beta Emissions (tpy)	Updated emissions (tpy)	%Total Difference
2610000500	VOC	372.49	78.94	-79%
2610000500	CO	5426.85	379.54	-93%
2610000500	NO_X	160.56	9.44	-94%
2610000500	PM_{25}-PRI	420.83	67.99	-84%
2610000500	PM_{10}-PRI	545.90	71.96	-87%
2610000500	NH_3	N/A	7.13	N/A
2610000500	SO_2	53.31	2.45	-95%

3. DEVELOPMENT OF MODEL-READY EMISSIONS

AQMs require a complete suite of all emissions (anthropogenic and biogenic) within the analysis areas as well as background emissions transported into the area. Table 8 summarizes the emission models and sources of emissions data to be used in the Louisville Ozone Formation Study. The Louisville Ozone Study CAMx modeling will use a 12/4-km nested grid structure as shown in Figure 3.

Figure 3

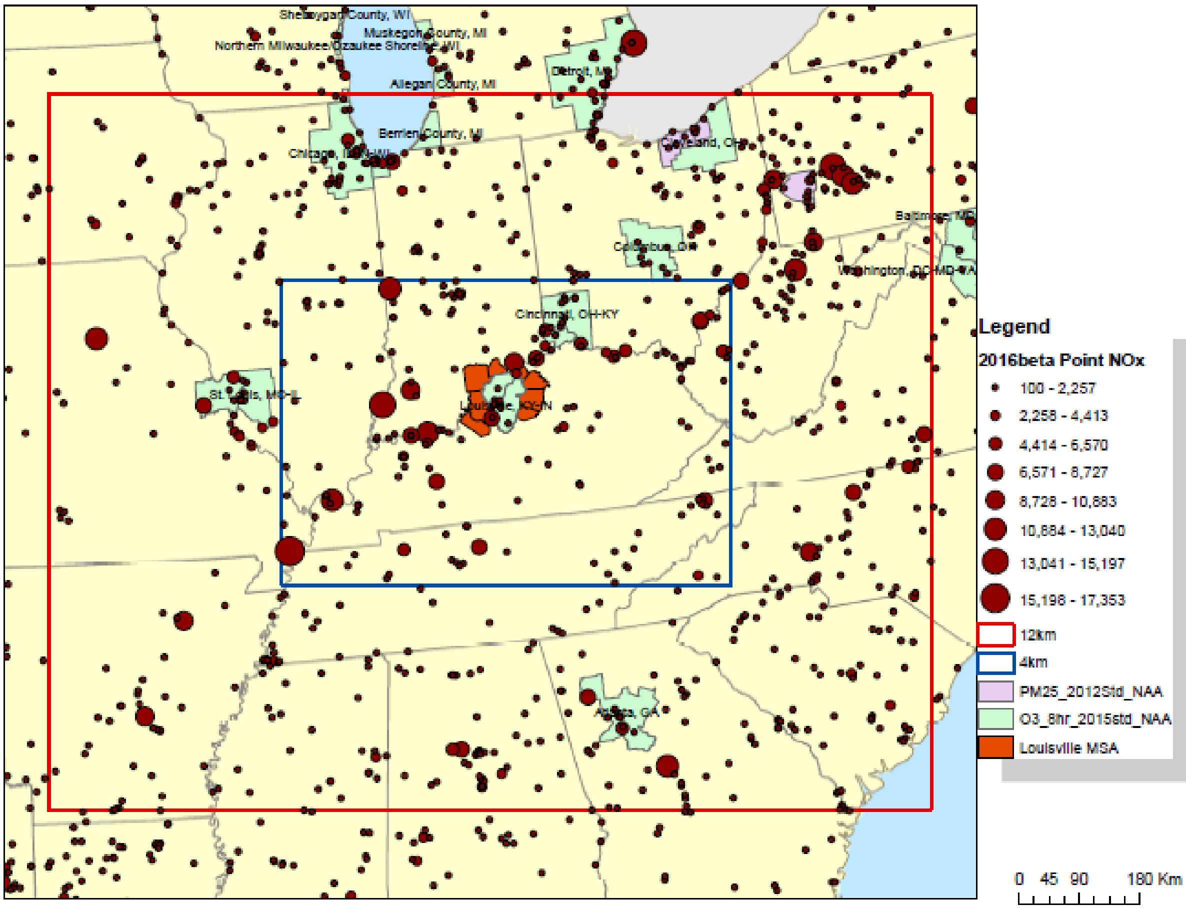

Figure 3The 12-km grid comprises Midwest domain that was extracted from the USEPA CONUS1 (12US1) domain[6] while the embedded 4-km Louisville grid is specific to this study's area of interest.

The updated inventory sectors have been processed using the SMOKE system (CMAS, 2018a) and merged with the 12-km Midwest domain emissions. During emissions processing, annual emissions inventories are speciated to model species, temporally allocated to hourly emissions, and spatially allocated to grid cells as follows.

Spatial Allocation: SMOKE uses spatial surrogates to spatially distribute emissions to modeling grid cells. Spatial surrogates are generated by overlaying the AQM modeling grid on maps of geospatial indicators appropriate to each source category (e.g., housing units).

[6] The 2016 platform is using the 12-km CONUS1 domain embedded in an expanded 36-km US3 domain

Temporal Allocation: We have processed the onroad emissions using weekly and diurnal temporal profiles from the EPA 2016beta platform. SMOKE has been used to allocate nonpoint emissions converted to point source and nonpoint annual emissions to months and across the diurnal cycle to account for seasonal, day-of-week, and hour-of-day effects.

Chemical Speciation: The emissions inventories include the following pollutants: CO, NOx, VOC, NH_3, SO_2, PM_{10}, and $PM_{2.5}$. The CB6r4 photochemical mechanism with active local methane emissions will be used for the CAMx modeling. We used SMOKE to convert inventoried VOC emissions into the CB6r4 mechanism-specific model species used in CAMx. Chemical speciation profiles have been assigned to inventory sources using cross-referencing data that match the profiles and inventory sources using country/state/county (FIPS) and SCCs. The team has used VOC and PM speciation profiles from the 2016beta platform. SMOKE also applied source-specific speciation profiles to convert inventoried NOx emissions to NO, NO_2, and nitrous acid (HONO) components. PM emissions have also been speciated to model species, namely primary organic aerosol (POA), primary elemental carbon (PEC), primary nitrate (PNO_3), primary sulfate (PSO_4), primary others (FPRM), and coarse PM (CPRM or $PM_{10-2.5}$).

Quality Assurance: The QA capabilities in SMOKE have been used to generate standard and custom reports for checking the emissions modeling process. SMOKE generates diagnostic files and summary reports which need to be carefully reviewed for error and warning messages.

Table 8. Summary of Sources for 2016 Base Case Emissions.

Emissions Component	Configuration/Data Sources	Details
Model	SMOKE	https://www.cmascenter.org/smoke. Latest version is SMOKE V4.6 released in September 2018.
Oil and Gas	EPA/MJO 2016beta emissions	EPA/MJO 2016beta inventory: http://views.cira.colostate.edu/iwdw/RequestData/Default.aspx?pid=USEPA_2016
Area	Reconciled nonpoint emissions for Jefferson County and 2016beta nonpoint emissions for rest of the domain. Jefferson Co permitted minor point sources were removed from the nonpoint inventory and processed in a separate SMOKE processing stream as point sources	EPA/MJO 2016beta inventory: http://views.cira.colostate.edu/iwdw/RequestData/Default.aspx?pid=USEPA_2016
Onroad Mobile	MOVES2014b for 5 counties in the Louisville MSA and SMOKE-MOVES for rest of the domain	http://www.epa.gov/otaq/models/moves/
EGU	2016 Continuous Emissions Monitor data for NO_x and SO_2	Clean Air Markets (CAMD) http://ampd.epa.gov/ampd/
Other Points (non-EGU)	EPA/MJO 2016beta emissions	EPA/MJO 2016beta inventory: http://views.cira.colostate.edu/iwdw/RequestData/Default.aspx?pid=USEPA_2016
Off-Road Mobile	EPA/MJO 2016beta emissions	EPA/MJO 2016beta inventory: http://views.cira.colostate.edu/iwdw/RequestData/Default.aspx?pid=USEPA_2016

Emissions Component	Configuration/Data Sources	Details
Fugitive Dust	EPA/MJO 2016beta emissions	EPA/MJO 2016beta inventory: http://views.cira.colostate.edu/iwdw/RequestData/Default.aspx?pid=USEPA_2016
Ammonia Emissions	EPA/MJO 2016beta emissions	EPA/MJO 2016beta inventory: http://views.cira.colostate.edu/iwdw/RequestData/Default.aspx?pid=USEPA_2016
Biogenic Sources	SMOKE-BEIS with 2016 meteorological data	Biogenic Emission Inventory System, version 3.61 (BEIS3.61) within SMOKE
Fires	2016 US BlueSky fires	2016 US BlueSky framework
Temporal Adjustments	Seasonal, monthly, day, hour	Based on collected information for the base case emissions.
Chemical Speciation	CB6r4	Revision 4 of Carbon Bond 6 chemical mechanism
Gridding	Spatial Surrogates based on land use and other geospatial data sources	Use spatial surrogates from the 2016beta EMP
Emission Controls	Source Category Specific	MOVES and the EPA inventory include effect of “on the books” regulations as assessed by EPA.
Quality Assurance	QA Tools in SMOKE; spatial plots; Summary reports	

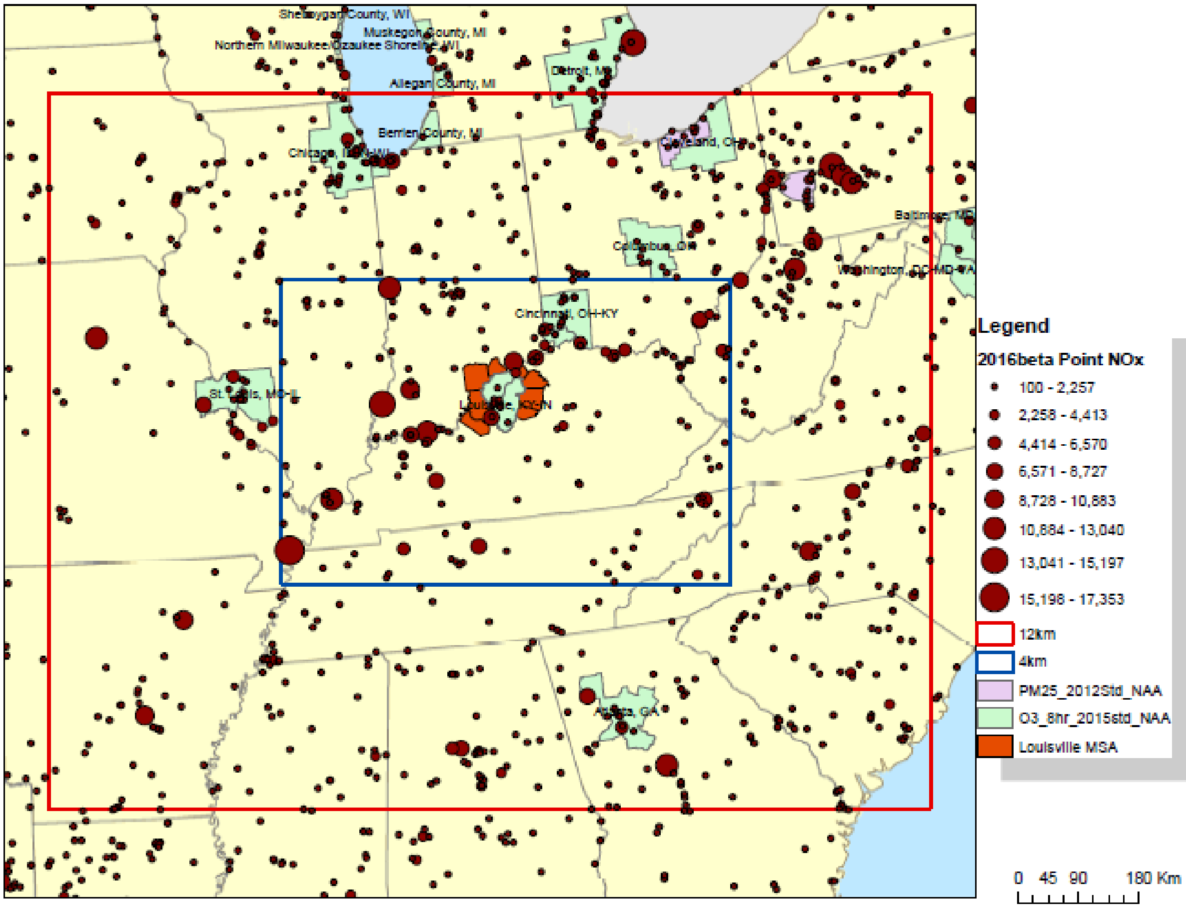

Figure 3. Map of 12/4-km flexi-nested CAMx modelling domains for the Louisville Ozone Study.

Ramboll conducted the SMOKE runs replacing the 2016beta nonpoint emissions from USEPA with data supplied by the LMAPCD. Details on SMOKE processing are provided below. The resulting nonpoint emissions have been reviewed and quality assured by generating plots and tables of emissions. The revised nonpoint emissions have been re-merged with the rest of the model-ready emissions inventory using SMOKE.

3.1 SMOKE Processing for Onroad Mobile Emissions

First, Ramboll converted the LMAPCD-provided onroad mobile source inventory for all criteria pollutants into SMOKE-ready input format. We assigned SCCs to each vehicle/fuel/process type combination in the inventory and flagged inventory pollutants with process information for speciation (EXH, RFL, EVP etc.) using detailed inventory data. We prepared monthly emissions files in Flat File 2010 (FF10) format for SMOKE input. The monthly FF10 inventory files were then processed through SMOKE.

SMOKE processing used ancillary files from the USEPA 2016beta platform for speciation, spatial, and temporal allocation[7]. Specifically, Ramboll processed the onroad monthly emissions with SMOKE using weekly and diurnal temporal profiles and chemical speciation

[7] EPA/MJO 2016beta Emissions Modeling Platform: Retrieved from http://views.cira.colostate.edu/iwdw/RequestData/Default.aspx?pid=USEPA_2016

ancillary files available from the 2016beta platform. In the FF10 inventory file, brake and tire wear emissions are aggregated under a single SCC for each vehicle/fuel type. Separate speciation for brake and tire wear emissions is applied using split factors specified through GSPRO_COMBO SMOKE file. We updated GSPRO_COMBO to use county-specific brake/tire wear splits based on the LMAPCD onroad inventory. A representative week from each month (seven days a month) was used to represent the entire month's emissions. Holidays were modeled separately as if they were a Sunday. Figure 4 presents gridded emissions for the updated onroad source category processed through SMOKE.

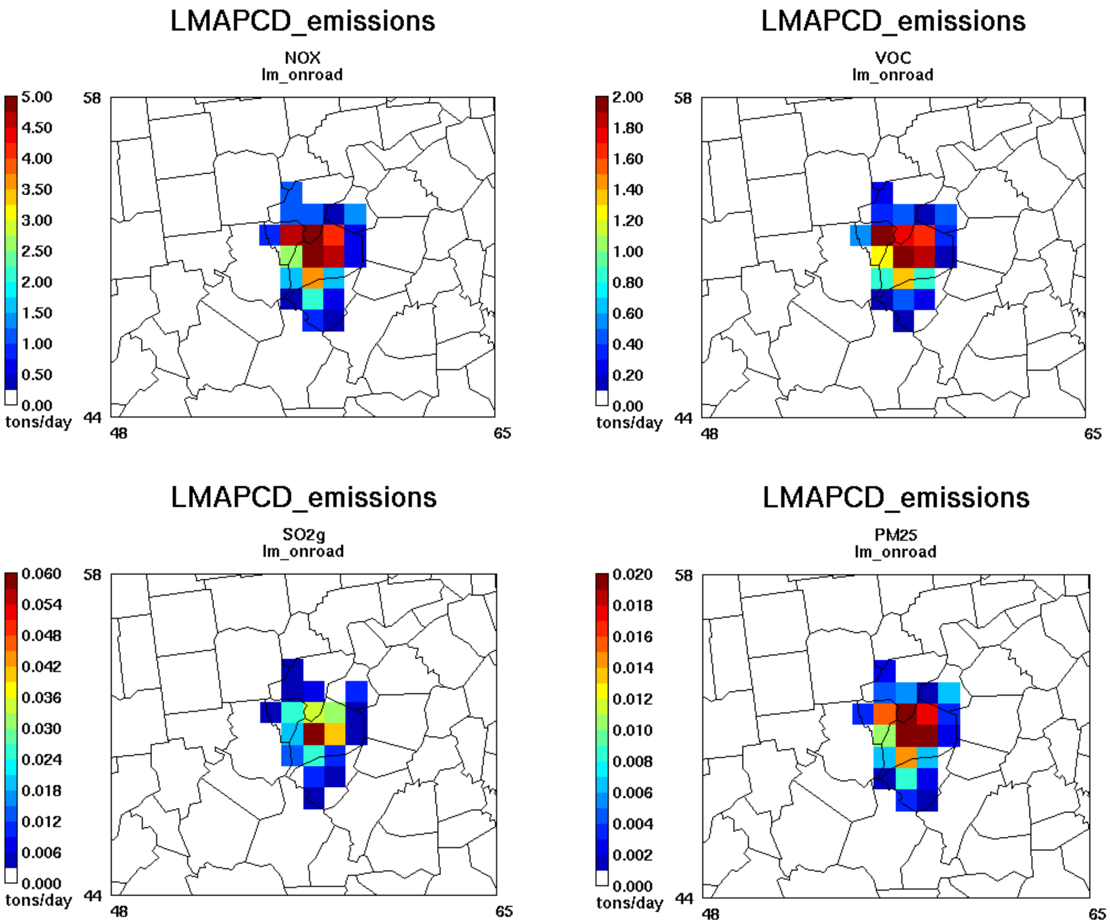

Figure 4. Spatial distribution of onroad NOx, VOC, $PM_{2.5}$ and SO_2 (clockwise starting from top left) emissions (tons per day) for Midwest 12 km domain.

To integrate the new onroad mobile emissions with the 2016 platform, we zeroed out existing onroad emissions within the five counties by masking 12-km grid cells using a cell-mask file shown in Figure 5. The cell-mask file was developed through the intersection of county shapefile with modeling grid. The revised USEPA 2016beta onroad files were then integrated with the LMAPCD-provided onroad files for complete onroad emissions.

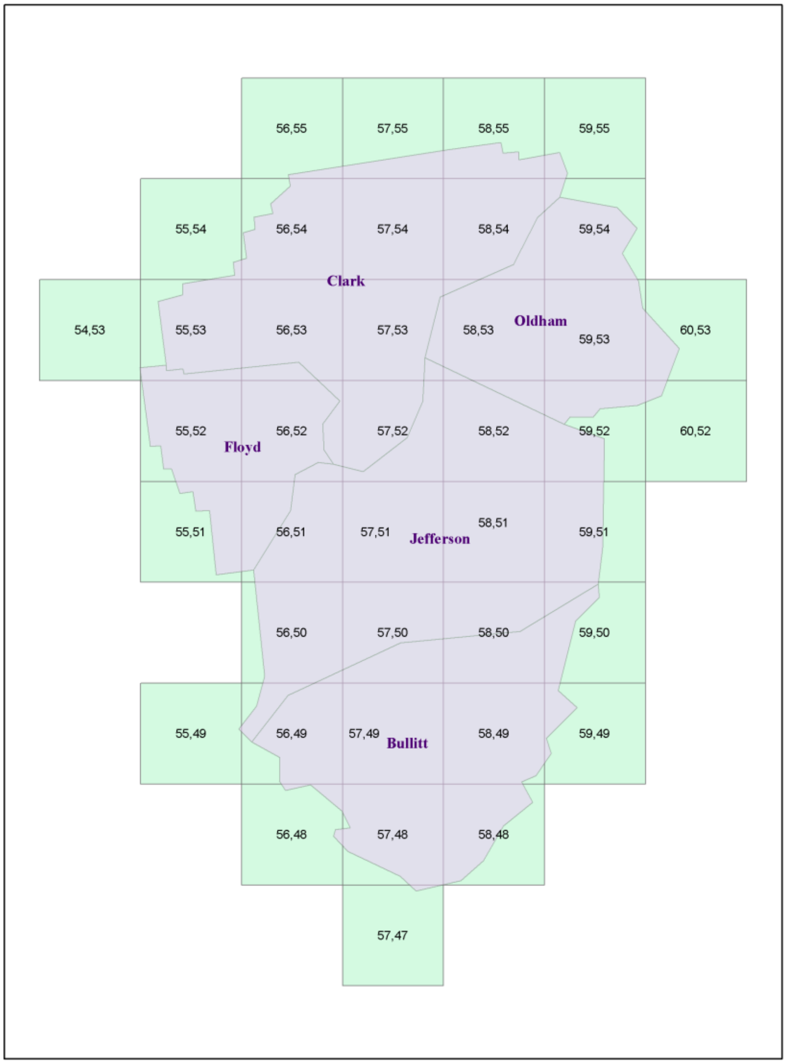

Figure 5. Cell mask file showing overlap between the five counties in Louisville MSA and modeling grid.

3.2 SMOKE Processing for Nonpoint Emissions Converted to Point Source Emissions

The LMAPCD provided local emissions by source for 2016 permitted through FEDOOP (Gary, B., 2019a). The data included emissions, location information and release characteristics. We converted minor source emissions into point FF10 format for SMOKE processing for bulk gas terminals and publicly owned treatment works. SMOKE processing used unmodified ancillary files from the USEPA 2016beta platform for speciation, spatial, and temporal allocation. A representative week from each month (seven days a month) was used to represent the entire month's emissions. Holidays were modeled separately as if they were a Sunday. The individual nonpoint source categories that were converted into point format are described in more detail in the following sections below. Figure 6 shows zoomed emissions plots for nonpoint sources converted to points. It includes bulk gas terminals and Morris Forman WWTP facilities.

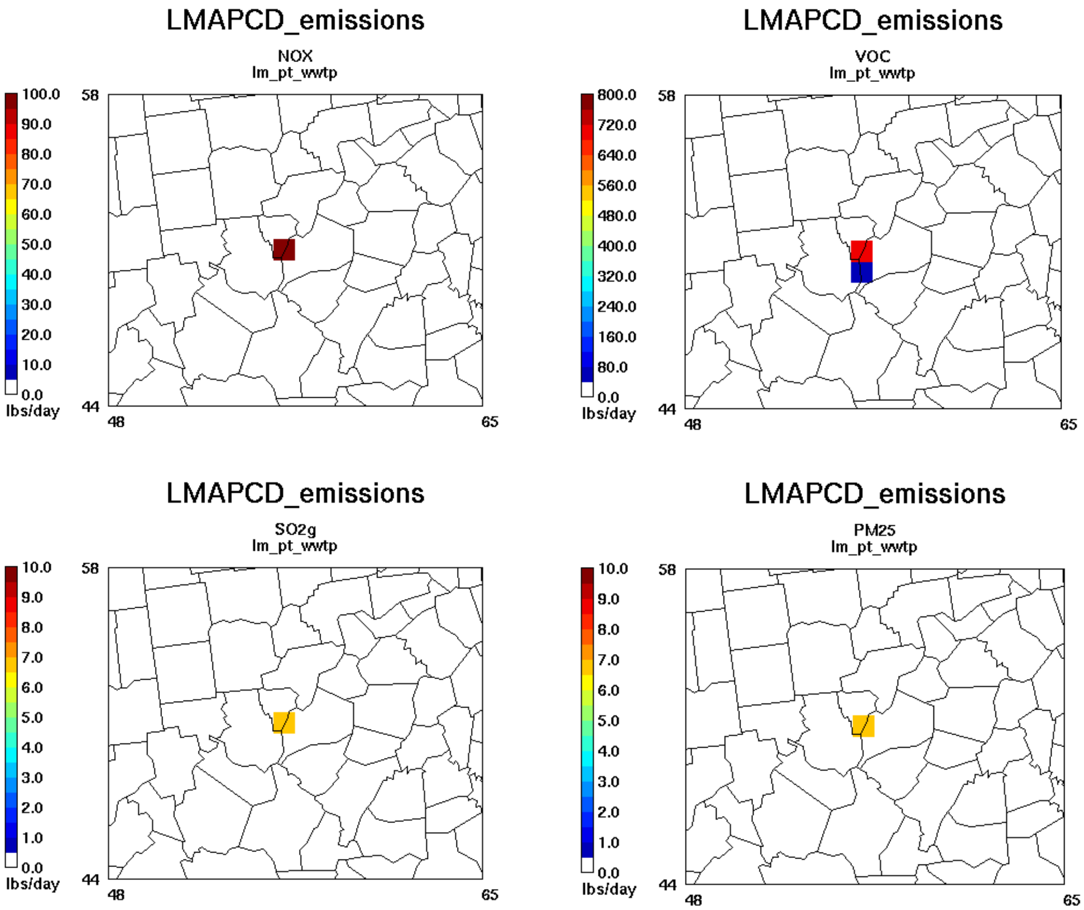

Figure 6. Spatial distribution of permitted minor source NOx, VOC, $PM_{2.5}$ and SO_2 (clockwise starting from top left) emissions (pounds per day) for the Midwest 12 km domain.

To combine those nonpoint emissions that are modeled as point sources with the USEPA 2016beta nonpoint inventory, the USEPA 2016beta nonpoint file was revised to remove emissions for corresponding SCC/county combinations to avoid any double counting and then reprocessed through SMOKE. The updated USEPA 2016beta nonpoint emissions and new point source emissions were merged with the rest of the model-ready emissions inventory.

3.2.1 Bulk Gas Terminals/Plants

All original USEPA bulk gas terminal/plant emissions were removed from the USEPA 2016beta nonpoint emissions. All the bulk gasoline terminal emissions (described in Section 2.2.1) were processed as point sources. SMOKE system was used to process emissions for the 12-km Midwest domain shown in Figure 3. Stack parameters information for these sources were not available, so USEPA 2016beta default release characteristics for similar SCC were used as shown in Table 9.

Table 9. Default stack parameters for bulk gas terminals based on SCC.

Facility Name	SCC	m	m	deg K	m/s
		Stk Ht	Stk Dm	Stk Tmp	Stk Vel
Buckeye Terminals, LLC	2501050000	3	0.2	295.4	4
Buckeye Terminals, LLC	2501050090	3	0.2	295.4	4
Buckeye Terminals, LLC	2501050120	3	0.2	295.4	4
MPLX Terminals, LLC	2501050000	3	0.2	295.4	4
MPLX Terminals, LLC	2501050090	3	0.2	295.4	4
MPLX Terminals, LLC	2501050120	3	0.2	295.4	4
Valero Terminaling and Distribution Company	2501050000	3	0.2	295.4	4
Valero Terminaling and Distribution Company	2501050030	3	0.2	295.4	4
Valero Terminaling and Distribution Company	2501050090	3	0.2	295.4	4
Valero Terminaling and Distribution Company	2501050120	3	0.2	295.4	4
Thornton Transportation LLC	2501050000	3	0.2	295.4	4
Thornton Transportation LLC	2501050120	3	0.2	295.4	4
VALOR, LLC	2501050120	3	0.2	295.4	4

3.2.2 Waste Disposal

The Metropolitan Sewer District, Morris Forman Waste Water Treatment Plant (WWTP) was processed as a point source as shown in Table 10. The LMAPCD provided stack parameters for the Morris Foreman WWTP (Gary, B., 2019b; Excel file “2019-05-24_MFWWTP_rel_pts”).

Table 10. Stack parameters for Morris Forman WWTP.

Facility Name	Stack ID	SCC	m	m	deg K	m/s
			Stk Ht	Stk Dm	Stk Tmp	Stk Vel
Metropolitan Sewer District, Morris Form	U1 F1	2630020001	3	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U1 F2	2630020001	3	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U1 F3	2630020001	3	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U2 F1	2630020001	0.91	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U2 F2	2630020001	3	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U3 F1	2630020001	3	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U3 S1	2630020001	14.02	0.52	297.04	22.38
Metropolitan Sewer District, Morris Form	U3 S2	2630020001	14.02	0.52	297.04	22.38
Metropolitan Sewer District, Morris Form	U4 F1	2630020001	3	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U4 F2	2630020001	3	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U4 F3	2630020001	3	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U4 F4	2630020001	1.52	0.2	295.4	4

Facility Name	Stack ID	SCC	m	m	deg K	m/s
			Stk Ht	Stk Dm	Stk Tmp	Stk Vel
Metropolitan Sewer District, Morris Form	U4 F5	2630020001	3	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U4 F6	2630020001	3	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U4 F7	2630020001	3	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U4 S1	2630020001	1.52	0.2	297.04	4.62
Metropolitan Sewer District, Morris Form	U4 S2	2630020001	1.52	0.2	297.04	4.62
Metropolitan Sewer District, Morris Form	U4 S3	2630020001	1.52	0.2	297.04	4.62
Metropolitan Sewer District, Morris Form	U5 F1	2630020001	3	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U6 F1	2630020001	9.75	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U6 F2	2630020001	9.75	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U6 F3	2630020001	9.75	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U6 F4	2630020001	9.75	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U6 S5	2630020001	10.97	2.74	1060.93	0.13
Metropolitan Sewer District, Morris Form	U7 S1	2630020001	12.19	0.61	297.04	63.71
Metropolitan Sewer District, Morris Form	U8 S1	2630020001	13.11	0.61	297.04	7.44
Metropolitan Sewer District, Morris Form	U8 S2	2630020001	13.11	0.61	297.04	7.44
Metropolitan Sewer District, Morris Form	U8 S3	2630020001	7.32	0.61	1060.93	2.02
Metropolitan Sewer District, Morris Form	U9 S1	2630020001	9.14	0.49	394.26	27.79
Metropolitan Sewer District, Morris Form	U9 S2	2630020001	9.14	0.49	394.26	27.79
Metropolitan Sewer District, Morris Form	U9 S3	2630020001	9.14	0.49	394.26	27.79
Metropolitan Sewer District, Morris Form	U9 S5	2630020001	5.06	0.2	308.15	162.56
Metropolitan Sewer District, Morris Form	U10 S1	2630020001	19.81	0.61	505.37	56.6
Metropolitan Sewer District, Morris Form	U10 S3	2630020001	5.18	0.2	344.26	500
Metropolitan Sewer District, Morris Form	U10 S5	2630020001	4.88	0.3	505.37	226.38
Metropolitan Sewer District, Morris Form	U11 S1	2630020001	1.83	0.08	394.26	500
Metropolitan Sewer District, Morris Form	U11 S2	2630020001	0.61	0.04	394.26	500
Metropolitan Sewer District, Morris Form	U12 S1	2630020001	22.86	0.2	324.26	336.3
Metropolitan Sewer District, Morris Form	U13 F1	2630020001	6.1	0.2	295.4	4
Metropolitan Sewer District, Morris Form	U13 F2	2630020001	6.1	0.2	295.4	4

3.3 SMOKE Processing for Nonpoint Emissions

The USEPA 2016beta nonpoint inventory file was updated to remove nonpoint emissions converted to point sources and include the updates for LMAPCD SCC/county emissions discussed in Chapter 2. SMOKE processing used default ancillary files from the USEPA 2016beta platform for speciation, spatial, and temporal allocation[8]. A representative week from each month (seven days a month) was used to represent the entire month's emissions. Holidays were modeled separately as if they were a Sunday. Figure 7 shows 2016 emissions

[8] EPA/MJO 2016beta Emissions Modeling Platform: Retrieved from http://views.cira.colostate.edu/iwdw/RequestData/Default.aspx?pid=USEPA_2016

for nonpoint sources after reconciliation with sources converted to points and other emissions updates described in Chapter 2 and Section 3.2.

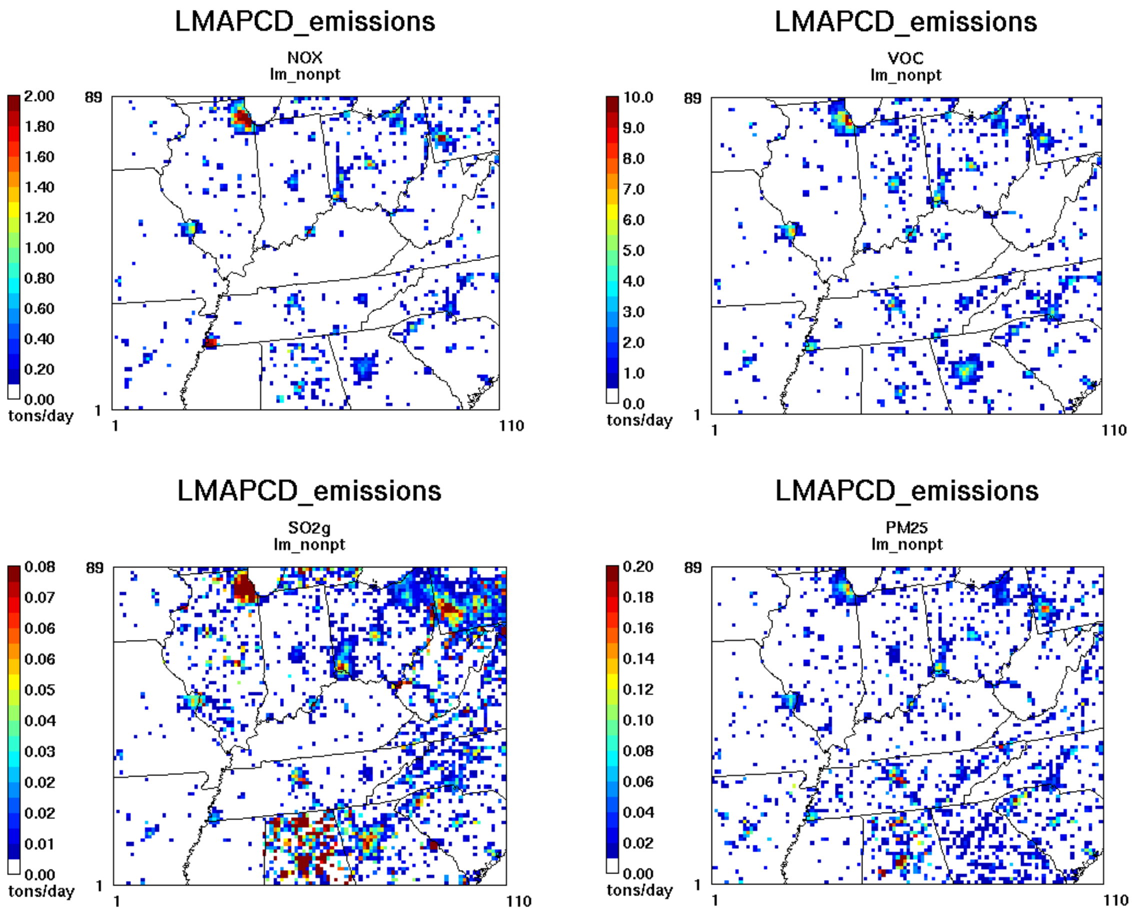

Figure 7. Spatial distribution of nonpoint NOx, VOC, $PM_{2.5}$ and SO_2 (clockwise starting from top left) emissions (tons per day) for the Midwest 12 km domain.

3.4 Summary of Emissions Modeling QA/QC Procedures

The emissions were processed by major source category in several different SMOKE "streams" described above in Sections 3.1, 3.2, and 3.3. This is done in order to assist in the quality assurance (QA) and quality control (QC) of the emissions modeling. SMOKE includes QA and reporting features to keep track of the adjustments at each step of emissions processing and to ensure that data integrity is not compromised. SMOKE generates diagnostic files and summary reports which were carefully reviewed for significant error and warning messages. We reviewed the SMOKE reports to confirm that appropriate source profiles are being used.

3.5 Summary of Emissions

This section presents emissions summary for the sectors processed through SMOKE. Table 11 summarizes criteria air pollutant emissions by month for onroad mobile sources within five counties in Louisville MSA in short tons per day. Emissions are summarized from the reports generated by SMOKE. Similarly, Table 12 provides emissions summary for bulk gas terminal and waste water treatment plant converted and processed as points. Table 13 presents 2016 emissions for nonpoint sources by SCC within Jefferson County.

Table 11. Onroad emissions summary by county and month from SMOKE reports (in short tons per day).

State	County	CO	NOx	NH_3	SO_2	PM_{10}	$PM_{2.5}$	EXH_TOG	EVP_TOG	EPM_TOG	RFL_TOG
March											
Indiana	Clark	30.36	8.42	0.15	0.04	0.48	0.25	1.85	0.48	0.07	0.07
Indiana	Floyd	26.36	5.31	0.09	0.02	0.30	0.16	1.93	0.61	0.13	0.04
Kentucky	Bullitt	17.76	6.24	0.09	0.03	0.31	0.19	1.31	0.31	0.06	0.03
Kentucky	Jefferson	127.68	27.07	0.67	0.20	1.85	0.89	7.40	2.18	0.40	0.17
Kentucky	Oldham	8.98	2.66	0.05	0.01	0.16	0.09	0.63	0.17	0.03	0.01
April											
Indiana	Clark	28.1	8.57	0.16	0.04	0.49	0.25	1.88	0.5	0.09	0.06
Indiana	Floyd	23.64	5.36	0.09	0.03	0.3	0.16	1.91	0.63	0.16	0.04
Kentucky	Bullitt	17.33	6.38	0.1	0.03	0.31	0.19	1.32	0.33	0.07	0.03
Kentucky	Jefferson	124.7	27.58	0.7	0.21	1.89	0.9	7.33	2.32	0.5	0.17
Kentucky	Oldham	8.7	2.71	0.05	0.01	0.17	0.09	0.63	0.18	0.04	0.01
May											
Indiana	Clark	30.58	8.54	0.16	0.04	0.51	0.26	1.99	0.50	0.12	0.07
Indiana	Floyd	23.70	5.36	0.09	0.03	0.31	0.16	1.99	0.64	0.20	0.04
Kentucky	Bullitt	17.81	6.27	0.10	0.03	0.32	0.19	1.33	0.32	0.09	0.03
Kentucky	Jefferson	128.13	27.09	0.72	0.21	1.92	0.90	7.40	2.28	0.63	0.17
Kentucky	Oldham	8.82	2.67	0.05	0.02	0.17	0.10	0.63	0.18	0.05	0.01
June											
Indiana	Clark	37.72	8.46	0.17	0.05	0.52	0.27	2.05	0.58	0.19	0.08
Indiana	Floyd	27.74	5.30	0.10	0.03	0.32	0.16	1.99	0.76	0.32	0.05
Kentucky	Bullitt	21.29	6.17	0.11	0.03	0.33	0.20	1.36	0.37	0.15	0.03
Kentucky	Jefferson	155.41	26.89	0.75	0.23	1.98	0.92	7.46	2.59	1.02	0.19
Kentucky	Oldham	10.36	2.62	0.05	0.02	0.18	0.10	0.63	0.21	0.09	0.01
July											
Indiana	Clark	40.23	8.27	0.17	0.05	0.53	0.27	2.08	0.58	0.21	0.09
Indiana	Floyd	29.21	5.20	0.10	0.03	0.32	0.16	2.00	0.76	0.35	0.05
Kentucky	Bullitt	22.53	6.02	0.11	0.03	0.33	0.20	1.37	0.37	0.16	0.03
Kentucky	Jefferson	165.19	26.33	0.76	0.24	2.00	0.93	7.53	2.61	1.12	0.20
Kentucky	Oldham	10.92	2.56	0.05	0.02	0.18	0.10	0.64	0.21	0.10	0.02
August											
Indiana	Clark	41.09	8.27	0.17	0.05	0.53	0.27	2.09	0.59	0.21	0.09
Indiana	Floyd	29.72	5.20	0.10	0.03	0.33	0.17	2.01	0.77	0.36	0.05
Kentucky	Bullitt	22.96	6.02	0.11	0.03	0.34	0.20	1.38	0.38	0.16	0.03
Kentucky	Jefferson	168.55	26.33	0.77	0.24	2.02	0.94	7.58	2.63	1.13	0.20
Kentucky	Oldham	11.12	2.56	0.05	0.02	0.18	0.10	0.64	0.21	0.10	0.02
September											

State	County	CO	NOx	NH_3	SO_2	PM_{10}	$PM_{2.5}$	EXH_TOG	EVP_TOG	EPM_TOG	RFL_TOG
Indiana	Clark	34.90	8.19	0.16	0.04	0.50	0.26	1.99	0.56	0.17	0.08
Indiana	Floyd	26.09	5.16	0.09	0.03	0.31	0.16	1.96	0.74	0.29	0.04
Kentucky	Bullitt	19.88	5.98	0.10	0.03	0.32	0.19	1.33	0.36	0.13	0.03
Kentucky	Jefferson	144.60	26.06	0.72	0.22	1.90	0.89	7.31	2.52	0.92	0.18
Kentucky	Oldham	9.73	2.55	0.05	0.02	0.17	0.09	0.62	0.20	0.08	0.01
October											
Indiana	Clark	29.98	8.41	0.16	0.04	0.49	0.25	1.87	0.53	0.12	0.07
Indiana	Floyd	24.39	5.26	0.09	0.03	0.30	0.15	1.86	0.68	0.20	0.04
Kentucky	Bullitt	18.29	6.25	0.10	0.03	0.32	0.19	1.30	0.35	0.09	0.03
Kentucky	Jefferson	132.37	27.08	0.71	0.21	1.89	0.89	7.15	2.49	0.64	0.18
Kentucky	Oldham	9.09	2.66	0.05	0.02	0.17	0.09	0.61	0.20	0.06	0.01

Table 12. SMOKE report emissions for bulk gas terminal and waste water treatment plant (in short tons per year).

Facility	CO	NH_3	NOx	PM_{10}-PRI	PM_{25}-PRI	SO_2	VOC
Buckeye Terminals, LLC							30.14
MPLX Terminals, LLC							43.66
Thornton Transportation LLC							13.69
Valero Terminaling and Distribution Company							50.10
VALOR, LLC							1.09
Metropolitan Sewer District, Morris Forman WWTP	23.55	0.90	28.25	17.77	10.42	1.21	6.43

Table 13. SMOKE report emissions for nonpoint sources within Jefferson County (in short tons per day).

SCC	SCC Description	CO	NH_3	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC
2102004001	Stationary Source Fuel Combustion;Industrial;Distillate Oil;All Boiler Types	0.020	0.003	0.079	0.009	0.006	0.029	0.001
2102004002	Stationary Source Fuel Combustion;Industrial;Distillate Oil;All IC Engine Types	0.338	0.002	1.570	0.113	0.106	0.019	0.109
2102005000	Stationary Source Fuel Combustion;Industrial;Residual Oil;Total: All Boiler Types	0.000	0.000	0.005	0.002	0.001	0.023	0.000
2102006000	Stationary Source Fuel Combustion;Industrial;Natural Gas;Total: Boilers and IC Engines	0.051	0.002	0.069	0.001	0.001	0.003	0.004
2102007000	Stationary Source Fuel Combustion;Industrial;Liquified Petroleum Gas (LPG);Total: All Boiler Types	0.005	0.000	0.008	0.000	0.000	0.000	0.000
2102008000	Stationary Source Fuel Combustion;Industrial;Wood;Total : All Boiler Types	2.095	0.024	0.768	1.805	1.561	0.087	0.059
2102011000	Stationary Source Fuel Combustion;Industrial;Kerosene;T otal: All Boiler Types	0.000	0.000	0.001	0.000	0.000	0.001	0.000

SCC	SCC Description	CO	NH_3	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC
2103004001	Stationary Source Fuel Combustion;Commercial/Institutional;Distillate Oil;Boilers	0.000	0.000	0.002	0.000	0.000	0.000	0.000
2103004002	Stationary Source Fuel Combustion;Commercial/Institutional;Distillate Oil;IC Engines	0.001	0.000	0.003	0.000	0.000	0.000	0.000
2103006000	Stationary Source Fuel Combustion;Commercial/Institutional;Natural Gas;Total: Boilers and IC Engines	1.002	0.006	1.193	0.006	0.005	0.007	0.066
2103007000	Stationary Source Fuel Combustion;Commercial/Institutional;Liquified Petroleum Gas (LPG);Total: All Combustor Types	0.049	0.000	0.087	0.000	0.000	0.000	0.003
2103008000	Stationary Source Fuel Combustion;Commercial/Institutional;Wood;Total: All Boiler Types	0.378	0.003	0.139	0.326	0.282	0.016	0.011
2103011000	Stationary Source Fuel Combustion;Commercial/Institutional;Kerosene;Total: All Combustor Types	0.000	0.000	0.001	0.000	0.000	0.001	0.000
2104004000	Stationary Source Fuel Combustion;Residential;Distillate Oil;Total: All Combustor Types	0.001	0.000	0.003	0.000	0.000	0.008	0.000
2104006000	Stationary Source Fuel Combustion;Residential;Natural Gas;Total: All Combustor Types	0.987	0.494	2.320	0.013	0.011	0.015	0.136
2104007000	Stationary Source Fuel Combustion;Residential;Liquified Petroleum Gas (LPG);Total: All Combustor Types	0.013	0.000	0.045	0.000	0.000	0.000	0.002
2104011000	Stationary Source Fuel Combustion;Residential;Kerosene;Total: All Heater Types	0.000	0.000	0.001	0.000	0.000	0.003	0.000
2302002100	Industrial Processes;Food and Kindred Products: SIC 20;Commercial Cooking - Charbroiling;Conveyorized Charbroiling	0.069	0.000	0.000	0.083	0.080	0.000	0.021
2302002200	Industrial Processes;Food and Kindred Products: SIC 20;Commercial Cooking - Charbroiling;Under-fired Charbroiling	0.216	0.000	0.000	0.550	0.532	0.000	0.066
2302003000	Industrial Processes;Food and Kindred Products: SIC 20;Commercial Cooking - Frying;Deep Fat Fying	0.000	0.000	0.000	0.000	0.000	0.000	0.011
2302003100	Industrial Processes;Food and Kindred Products: SIC 20;Commercial Cooking - Frying;Flat Griddle Frying	0.017	0.000	0.000	0.140	0.107	0.000	0.008
2302003200	Industrial Processes;Food and Kindred Products: SIC 20;Commercial Cooking - Frying;Clamshell Griddle Frying	0.000	0.000	0.000	0.010	0.009	0.000	0.000
2401001000	Solvent Utilization;Surface Coating;Architectural Coatings;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	2.447
2401005000	Solvent Utilization;Surface Coating;Auto Refinishing: SIC 7532;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.563

SCC	SCC Description	CO	NH_3	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC
2401008000	Solvent Utilization;Surface Coating;Traffic Markings;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.395
2401015000	Solvent Utilization;Surface Coating;Factory Finished Wood: SIC 2426 thru 242;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.021
2401020000	Solvent Utilization;Surface Coating;Wood Furniture: SIC 25;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.225
2401025000	Solvent Utilization;Surface Coating;Metal Furniture: SIC 25;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.209
2401030000	Solvent Utilization;Surface Coating;Paper: SIC 26;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.093
2401040000	Solvent Utilization;Surface Coating;Metal Cans: SIC 341;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.437
2401055000	Solvent Utilization;Surface Coating;Machinery and Equipment: SIC 35;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.062
2401060000	Solvent Utilization;Surface Coating;Large Appliances: SIC 363;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.378
2401065000	Solvent Utilization;Surface Coating;Electronic and Other Electrical: SIC 36 - 363;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.005
2401070000	Solvent Utilization;Surface Coating;Motor Vehicles: SIC 371;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	2.527
2401075000	Solvent Utilization;Surface Coating;Aircraft: SIC 372;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.006
2401085000	Solvent Utilization;Surface Coating;Railroad: SIC 374;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.018
2401090000	Solvent Utilization;Surface Coating;Miscellaneous Manufacturing;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.135
2401100000	Solvent Utilization;Surface Coating;Industrial Maintenance Coatings;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.631
2401200000	Solvent Utilization;Surface Coating;Other Special Purpose Coatings;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.006
2415000000	Solvent Utilization;Degreasing;All Processes/All Industries;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	2.427
2420000000	Solvent Utilization;Dry Cleaning;All Processes;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.041
2425000000	Solvent Utilization;Graphic Arts;All Processes;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	9.561
2460100000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All Personal Care Products;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	2.092

SCC	SCC Description	CO	NH_3	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC
2460200000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All Household Products;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	2.301
2460400000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All Automotive Aftermarket Products;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	1.422
2460500000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All Coatings and Related Products;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.994
2460600000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All Adhesives and Sealants;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.596
2460800000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All FIFRA Related Products;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	1.862
2460900000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;Miscellaneous Products (Not Otherwise Covered);Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.073
2461021000	Solvent Utilization;Miscellaneous Non-industrial: Commercial;Cutback Asphalt;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	0.138
2461022000	Solvent Utilization;Miscellaneous Non-industrial: Commercial;Emulsified Asphalt;Total: All Solvent Types	0.000	0.000	0.000	0.000	0.000	0.000	1.177
2461850000	Solvent Utilization;Miscellaneous Non-industrial: Commercial;Pesticide Application: Agricultural;All Processes	0.000	0.000	0.000	0.000	0.000	0.000	0.006
2501011011	Storage and Transport;Petroleum and Petroleum Product Storage;Residential Portable Gas Cans;Permeation	0.000	0.000	0.000	0.000	0.000	0.000	0.076
2501011012	Storage and Transport;Petroleum and Petroleum Product Storage;Residential Portable Gas Cans;Evaporation (includes Diurnal losses)	0.000	0.000	0.000	0.000	0.000	0.000	0.085
2501011013	Storage and Transport;Petroleum and Petroleum Product Storage;Residential Portable Gas Cans;Spillage During Transport	0.000	0.000	0.000	0.000	0.000	0.000	0.089
2501011014	Storage and Transport;Petroleum and Petroleum Product Storage;Residential Portable Gas Cans;Refilling at the Pump - Vapor Displacement	0.000	0.000	0.000	0.000	0.000	0.000	0.014
2501011015	Storage and Transport;Petroleum and Petroleum Product Storage;Residential Portable Gas Cans;Refilling at the Pump - Spillage	0.000	0.000	0.000	0.000	0.000	0.000	0.002

SCC	SCC Description	CO	NH_3	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC
2501012011	Storage and Transport;Petroleum and Petroleum Product Storage;Commercial Portable Gas Cans;Permeation	0.000	0.000	0.000	0.000	0.000	0.000	0.003
2501012012	Storage and Transport;Petroleum and Petroleum Product Storage;Commercial Portable Gas Cans;Evaporation (includes Diurnal losses)	0.000	0.000	0.000	0.000	0.000	0.000	0.003
2501012013	Storage and Transport;Petroleum and Petroleum Product Storage;Commercial Portable Gas Cans;Spillage During Transport	0.000	0.000	0.000	0.000	0.000	0.000	0.122
2501012014	Storage and Transport;Petroleum and Petroleum Product Storage;Commercial Portable Gas Cans;Refilling at the Pump - Vapor Displacement	0.000	0.000	0.000	0.000	0.000	0.000	0.041
2501012015	Storage and Transport;Petroleum and Petroleum Product Storage;Commercial Portable Gas Cans;Refilling at the Pump - Spillage	0.000	0.000	0.000	0.000	0.000	0.000	0.005
2501060053	Storage and Transport;Petroleum and Petroleum Product Storage;Gasoline Service Stations;Stage 1: Balanced Submerged Filling	0.000	0.000	0.000	0.000	0.000	0.000	0.322
2501060201	Storage and Transport;Petroleum and Petroleum Product Storage;Gasoline Service Stations;Underground Tank: Breathing and Emptying	0.000	0.000	0.000	0.000	0.000	0.000	0.456
2501080050	Storage and Transport;Petroleum and Petroleum Product Storage;Airports : Aviation Gasoline;Stage 1: Total	0.000	0.000	0.000	0.000	0.000	0.000	0.098
2501080100	Storage and Transport;Petroleum and Petroleum Product Storage;Airports : Aviation Gasoline;Stage 2: Total	0.000	0.000	0.000	0.000	0.000	0.000	0.003
2505030120	Storage and Transport;Petroleum and Petroleum Product Transport;Truck;Gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.030
2505040120	Storage and Transport;Petroleum and Petroleum Product Transport;Pipeline;Gasoline	0.000	0.000	0.000	0.000	0.000	0.000	0.139
2610000100	Waste Disposal, Treatment, and Recovery;Open Burning;All Categories;Yard Waste - Leaf Species Unspecified	0.004	0.000	0.000	0.001	0.001	0.000	0.001
2610000400	Waste Disposal, Treatment, and Recovery;Open Burning;All Categories;Yard Waste - Brush Species Unspecified	0.005	0.000	0.000	0.001	0.000	0.000	0.001
2610000500	Waste Disposal, Treatment, and Recovery;Open Burning;All Categories;Land Clearing Debris (use 28-10-005-000 for Logging Debris Burning)	1.040	0.020	0.026	0.197	0.186	0.007	0.216
2610030000	Waste Disposal, Treatment, and Recovery;Open Burning;Residential;Household	0.139	0.000	0.010	0.045	0.042	0.002	0.009

SCC	SCC Description	CO	NH_3	NOx	PM_{10}	$PM_{2.5}$	SO_2	VOC
	Waste (use 26-10-000-xxx for Yard Wastes)							
2630020000	Waste Disposal, Treatment, and Recovery;Wastewater Treatment;Public Owned;Total Processed	0.000	0.003	0.000	0.000	0.000	0.000	0.011
2680003000	Waste Disposal, Treatment, and Recovery;Composting;100% Green Waste (e.g., residential or municipal yard wastes);All Processes	0.000	0.050	0.000	0.000	0.000	0.000	0.353
2810025000	Miscellaneous Area Sources;Other Combustion;Charcoal Grilling - Residential (see 23-02-002-xxx for Commercial);Total	1.758	0.000	0.038	0.123	0.098	0.000	0.033
2810060100	Miscellaneous Area Sources;Other Combustion;Cremation;Humans	0.000	0.000	0.010	0.001	0.001	0.002	0.000
Grand Total		**8.188**	**0.608**	**6.376**	**3.427**	**3.029**	**0.222**	**33.460**

4. FINAL MODEL-READY EMISSIONS

The emissions provided by LMAPCD were used to update and/or replace USEPA 2016beta emissions as described in Chapter 2. The revised emissions files were processed as described in Chapter 3. This chapter provides an overview of the final merging process and resulting model-ready emissions that will be used in the Louisville Ozone Formation Study for the CAMx AQM.

4.1 CAMx-Ready Emissions Inputs

The final step in developing the model-ready emissions was to combine sector-specific gridded, speciated, hourly emissions together. The unmerged sector emissions in CMAQ-ready format were merged together using the SMOKE "mrggrid" program. The merged CMAQ-ready emissions were then converted into the format needed by CAMx using a convertor program. We converted the CMAQ 2-D and in-line point emissions files to CAMx area-/point-source emissions files using the CMAQ2CAMx interface program available at http://www.camx.com/download/support-software.aspx. Next, the Louisville Ozone Study 12-km CAMx modeling domain was "windowed" out from the continental US domain, meaning the 12-km CAMx domain for this project was extracted from the US domain.

All pre-merged emissions components have been merged together to generate the final CAMx-ready two-dimensional gridded low-level (layer 1) and point source emission inputs. The CAMx photochemical grid model requires two types of emissions files, as described below, for every episode day; both types are FORTRAN binary files.

- Surface-level two-dimensional emissions: This file contains all sources other than elevated point sources that have no or little plume rise, so are emitted directly into the lowest (surface) layer of the model. SMOKE outputs gridded, speciated, hourly emissions files (one for each day) for each source category. The component emissions are then merged together into one surface layer emissions file.
- Elevated point source emissions: This file typically consists of emissions from major stationary point sources and includes stack parameters for each source so that plume rise may be calculated within CAMx. SMOKE outputs speciated hourly point source emissions files with stack parameters in an ASCII format that are converted into FORTRAN binary format that is readable by CAMx. If multiple point source files are produced for one day, they are merged together into one file.

The surface-level file is a gridded file that is matched to a specific modeling grid. Therefore, we have generated CAMx model-ready emission files for the 12-km modeling domain shown in Figure 3. The elevated point source file is independent of the modeling grid, because it contains horizontal (x, y) coordinates for each point source, and includes all point sources in the 12-km modeling grid.

Figure 8 shows the merged surface-level NOx emissions plots and comparison with the 2016beta emissions. The top panel shows emissions for the 12-km domain (right) and the USEPA 2106beta emissions for the same domain (left). The bottom panel shows NOx emissions difference plot for the full domain extent (left) and zoomed plot focusing on the Louisville MSA (right). The onroad emissions updates in the Louisville MSA are clearly evident in the plot. Similarly, Figure 9 through 11 show CAMx-ready emissions and comparison with the 2016beta for VOC, SO_2 and $PM_{2.5}$, respectively. The point source emissions were obtained from the 2016beta platform in CAMx-ready format, "windowed" out the Louisville Ozone Study 12-km domain and merged with nonpoint emissions converted to point source emissions.

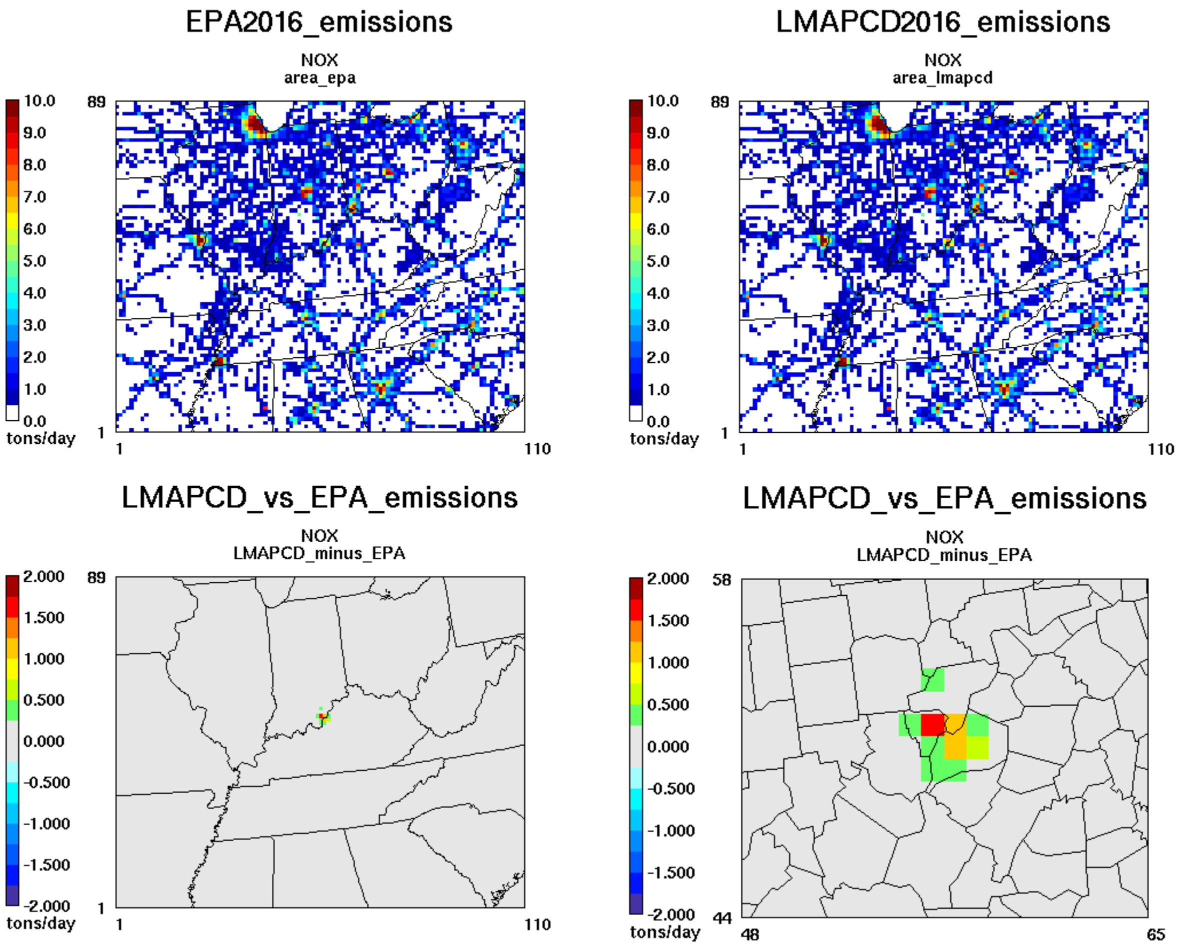

Figure 8. Spatial distribution of model-ready surface-level NOx emissions (tons per day) for LMAPCD 4 km domain and emissions difference plot against the 2016beta

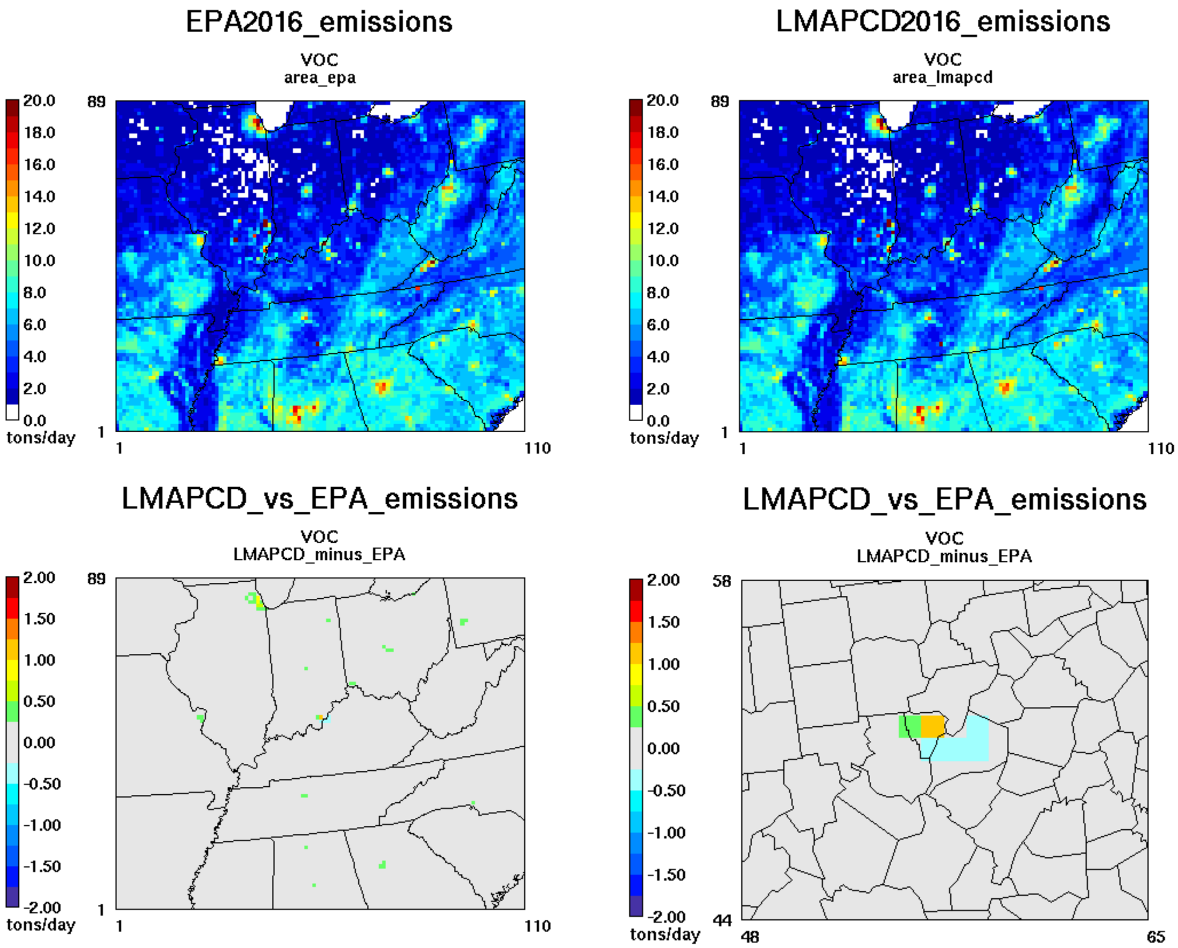

Figure 9. Spatial distribution of model-ready surface-level VOC emissions (tons per day) for LMAPCD 4 km domain and emissions difference plot against the 2016beta

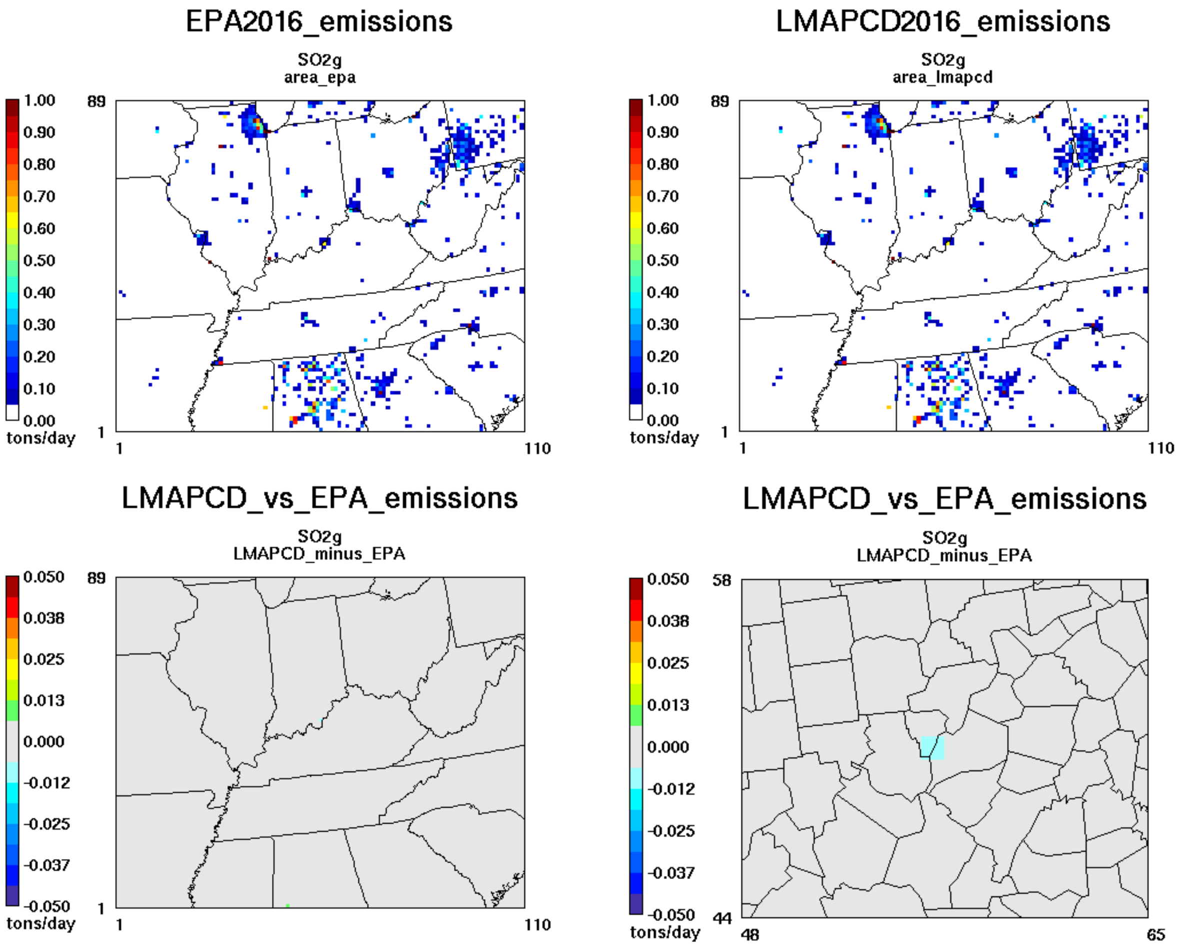

Figure 10. Spatial distribution of model-ready surface-level SO_2 emissions (tons per day) for LMAPCD 4 km domain and emissions difference plot against the 2016beta

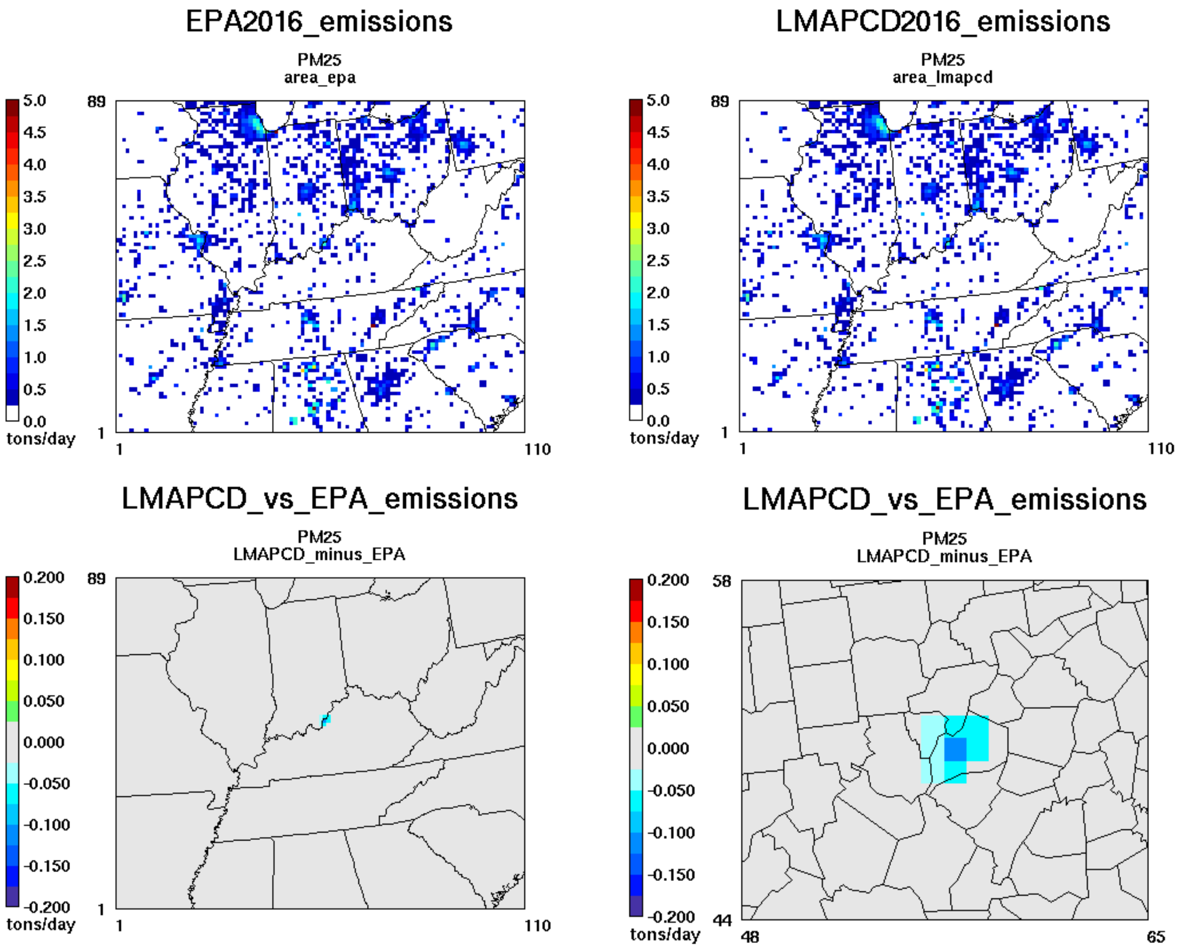

Figure 11. Spatial distribution of model-ready surface-level $PM_{2.5}$ emissions (tons per day) for LMAPCD 4 km domain and emissions difference plot against the 2016beta

5. REFERENCES

AAI, 2018. BenMAP Environmental Benefits Mapping and Analysis Program – Community Edition User's Manual. Prepared for US Environmental Protection Agency, Abt Associates Inc., Cambridge, Massachusetts.

Butler, C., 2019. LMAPCD personal communication, 29 May.

Gary, B., 2019a. LMAPCD personal communication, 21 May.

Gary, B., 2019b. LMAPCD personal communication, 24 May.

CMAS, 2018a. Community Modeling and Analysis Center. CMAS SMOKE web site: http://www.smokemodel.org

Ramboll, 2019. Louisville Metropolitan Air Pollution Control District Emissions Inventory Quality Assurance Project Plan. Prepared for Louisville Metropolitan Air Pollution Control District, Louisville, KY. Prepared by Ramboll. July

USEPA, 2014a. Motor Vehicle Emissions Simulator (MOVES) – User Guide for MOVES2014. Assessment and Standards Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. (EPA-420-B-14-055). July. (http://www.epa.gov/oms/models/moves/documents/420b14055.pdf).

USEPA, 2014b. Motor Vehicle Emissions Simulator (MOVES) –MOVES2014 User Interface Manual. Assessment and Standards Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. (EPA-420-B-14-067). July. (http://www.epa.gov/oms/models/moves/documents/420b14057.pdf).

USEPA, 2014c. Motor Vehicle Emissions Simulator (MOVES) –MOVES2014 Software Design Reference Manual. Assessment and Standards Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. (EPA-420-B-14-058). December. (http://www.epa.gov/oms/models/moves/documents/420b14056.pdf).

USEPA, 2018a. Modeling Guidance for Demonstrating Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Air Assessment Division. Research Triangle Park, NC. EPA 454/R-18-009. November 29. (https://www3.epa.gov/ttn/scram/guidance/guide/O3-PM-RH-Modeling_Guidance-2018.pdf).

USEPA, 2018b. 2014 National Emissions Inventory, Version 2. Available at: https://www.epa.gov/sites/production/files/2018-06/documents/nei2014v2_tsd_09may2018.pdf

U.S. Forest Service, 2019. PNW Research Station. *BlueSky Playground*, 3.0 Alpha. (http://tools.airfire.org/playground/v3/emissionsinputs.php) Accessed July, 2019.